DOCUMENT RESUME

ED 220 678 CE 033 641

| | |
|---|---|
| TITLE | Military Curriculum Materials for Vocational and Technical Education. Carpentry II, 3-8B. |
| INSTITUTION | Army Engineer School, Fort Belvoir, Va.; Ohio State Univ., Columbus. National Center for Research in Vocational Education. |
| SPONS AGENCY | Office of Education (DHEW), Washington, D.C. |
| PUB DATE | [78] |
| NOTE | 145p.; For a related document see CE 033 640. |
| EDRS PRICE | MF01/PC06 Plus Postage. |
| DESCRIPTORS | Basic Skills; *Building Design; *Carpentry; *Construction (Process); *Construction Materials; Correspondence Study; Independent Study; Learning Activities; Lesson Plans; Postsecondary Education; *Programed Instructional Materials; Roofing; Secondary Education; Test Items; Units of Study; Woodworking |
| IDENTIFIERS | Military Curriculum Project |

ABSTRACT

This individualized, self-paced correspondence course in carpentry has been adapted from military curriculum materials for use in vocational and technical education programs. This second volume of a two-volume set is designed to present the theory portion of carpentry through the teaching of basic skills of frame construction. This Carpentry II course contains 4 lessons. Lesson 1, Building Layout and Floor Framing, discusses the location and layout of a building site and the methods and materials to be used in construction foundations. Lesson 2, Exterior Framing, explains how to make a building layout and do floor framing, and the purpose and use of sills, girders, joints, and bridging. In lesson 3, Roof Framing and Materials, the methods and procedures for constructing roof frames and coverings, including the selection of materials and the use of tools, are discussed. The final lesson, Interior Framing, explains the methods for installing and maintaining interior walls and ceiling, doors and window trims, and floors and stairways. Each lesson contains an objective with reading assignments, exercises, and answers to the exercises. The answers are keyed to the text for student self-study and evaluation. A course examination, without answers, is provided. (This course is recommended for use in a shop or on-the-job learning situation.) (KC)

# MILITARY CURRICULUM MATERIALS

The military-developed curriculum materials in this course package were selected by the National Center for Research in Vocational Education Military Curriculum Project for dissemination to the six regional Curriculum Coordination Centers and other instructional materials agencies. The purpose of disseminating these courses was to make curriculum materials developed by the military more accessible to vocational educators in the civilian setting.

The course materials were acquired, evaluated by project staff and practitioners in the field, and prepared for dissemination. Materials which were specific to the military were deleted, copyrighted materials were either omitted or approval for their use was obtained. These course packages contain curriculum resource materials which can be adapted to support vocational instruction and curriculum development.

# The National Center Mission Statement

The National Center for Research in Vocational Education's mission is to increase the ability of diverse agencies, institutions, and organizations to solve educational problems relating to individual career planning, preparation, and progression. The National Center fulfills its mission by:

- Generating knowledge through research
- Developing educational programs and products
- Evaluating individual program needs and outcomes
- Installing educational programs and products
- Operating information systems and services
- Conducting leadership development and training programs

FOR FURTHER INFORMATION ABOUT
Military Curriculum Materials
WRITE OR CALL
Program Information Office
The National Center for Research in Vocational Education
The Ohio State University
1960 Kenny Road, Columbus, Ohio 43210
Telephone: 614/486-3655 or Toll Free 800/848-4815 within the continental U.S. (except Ohio)

THE NATIONAL CENTER FOR RESEARCH IN VOCATIONAL EDUCATION

# Military Curriculum Materials for Vocational and Technical Education

Information and Field Services Division

The National Center for Research in Vocational Education

# Military Curriculum Materials Dissemination Is . . .

an activity to increase the accessibility of military-developed curriculum materials to vocational and technical educators.

This project, funded by the U.S. Office of Education, includes the identification and acquisition of curriculum materials in print form from the Coast Guard, Air Force, Army, Marine Corps and Navy.

Access to military curriculum materials is provided through a "Joint Memorandum of Understanding" between the U.S. Office of Education and the Department of Defense.

The acquired materials are reviewed by staff and subject matter specialists, and courses deemed applicable to vocational and technical education are selected for dissemination.

The National Center for Research in Vocational Education is the U.S. Office of Education's designated representative to acquire the materials and conduct the project activities.

Project Staff:

Wesley E. Budke, Ph.D., Director
National Center Clearinghouse

Shirley A. Chase, Ph.D.
Project Director

# What Materials Are Available?

One hundred twenty courses on microfiche (thirteen in paper form) and descriptions of each have been provided to the vocational Curriculum Coordination Centers and other instructional materials agencies for dissemination.

Course materials include programmed instruction, curriculum outlines, instructor guides, student workbooks and technical manuals.

The 120 courses represent the following sixteen vocational subject areas:

- Agriculture
- Aviation
- Building & Construction Trades
- Clerical Occupations
- Communications
- Drafting
- Electronics
- Engine Mechanics
- Food Service
- Health
- Heating & Air Conditioning
- Machine Shop
- Management & Supervision
- Meteorology & Navigation
- Photography
- Public Service

The number of courses and the subject areas represented will expand as additional materials with application to vocational and technical education are identified and selected for dissemination.

# How Can These Materials Be Obtained?

Contact the Curriculum Coordination Center in your region for information on obtaining materials (e.g., availability and cost). They will respond to your request directly or refer you to an instructional materials agency closer to you.

CURRICULUM COORDINATION CENTERS

EAST CENTRAL
Rebecca S. Douglass
Director
100 North First Street
Springfield, IL 62777
217/782-0759

NORTHWEST
William Daniels
Director
Building 17
Airdustrial Park
Olympia, WA 98504
206/753-0879

MIDWEST
Robert Patton
Director
1515 West Sixth Ave.
Stillwater, OK 74704
405/377-2000

SOUTHEAST
James F. Shill, Ph.D.
Director
Mississippi State University
Drawer DX
Mississippi State, MS 39762
601/325-2510

NORTHEAST
Joseph F. Kelly, Ph.D.
Director
225 West State Street
Trenton, NJ 08625
609/292-6562

WESTERN
Lawrence F. H. Zane, Ph.D.
Director
1776 University Ave.
Honolulu, HI 96822
808/948-7834

ENGINEER 108

SUBCOURSE 532-0

Essayons

# CARPENTRY II

## ( FRAME CONSTRUCTION )

## CORRESPONDENCE COURSE
## U.S. ARMY ENGINEER SCHOOL

FORT BELVOIR, VIRGINIA 3-8

MOS: 51B20

EDITION 0 (NRI 011)

8

# INTRODUCTION

This subcourse and accompanying memorandum is a continuation of your instruction in carpentry. It emphasizes frame construction and constitutes another step in your career development.

Much of the material in Subcourse 531 will have further application here in the instruction pertaining to the making of doors and windows, the use of roof covering materials, the erection of walls and the laying of floors. Allied carpentry work, such as external trim, wall sheathing, and stairway construction, are also explained.

This subcourse consists of four lessons and an examination as follows:

Lesson 1. Building Layout and Floor Framing.

2. Exterior Framing.

3. Roof Framing and Materials.

4. Interior Framing.

Examination.

Fifteen credit hours are allowed for this subcourse. You will not be limited as to the number of hours that you spend on the subcourse, any lesson, or the examination. For statistical purposes, you are required to enter in the proper space on each answer sheet the number of hours spent in studying the text and solving the exercises.

Text furnished: Memorandum 532. The text need not be returned. To facilitate removal, answer sheets are bound in reverse order at the end of the booklet. Make sure that the number on the answer sheet is the same as the lesson you are working on. Each exercise has four choices with only ONE best answer. Select the choice you believe is best. Then turn to the answer sheet and mark an X through the letter representing that choice.

The examination will be sent to you when you have successfully completed all the lessons.

/10

# LESSON 1

## BUILDING LAYOUT AND FLOOR FRAMING

**CREDIT HOURS** ________________________ 4

**TEXT ASSIGNMENT** ____________________ Study chapter 1 of Memorandum 532.

**LESSON OBJECTIVE** ____________________ To teach you how to locate and lay out a building site and the methods and materials to be used in constructing foundations.

---

### EXERCISES

Solve the following multiple-choice exercises.

1. The most common type of concrete form is the full unit form. You would use it when

   a. the wall must be poured in a continuous operation

   b. the amount of form lumber used is unimportant

   c. time for constructing the wall is limited

   d. a long wall is to be built in sections

2. After you have your permanent building lines in place, how would you check to see if your work is square?

   a. measure the diagonals of the building

   b. use a steel square

   c. measure the length of the lines

   d. use a transit level

3. Why would you use the "Three, Four, Five" rule while laying out a building site?

   a. to square second side with first side

   b. to properly locate the second corner

   c. to square the fourth side with the third side

   d. to properly locate the first corner

4. Because of their almost universal use in framing buildings and their availability at the building site, which of these boards would you use to make your concrete form supporters and stakes?

   a. 2 x 6's    c. 2 x 4's

   b. 1 x 4's    d. 1 x 6's

5. On the construction job on which you are working, the footing must be poured before the foundation wall. How do you prevent shifting of the wall on the footing?

   a. increase the width of the wall

   b. use keyways or metal pins

   c. increase width of the footing

   d. tilt the foundation toward the load

6. You are constructing a frame building which will be covered with wooden siding over the sheathing. Where do you place the sills?

a. flush with outside edge of foundation

b. ¾ inch from outside edge of foundation

c. equal distance from edges of foundation

d. 2⅝ inch from outside edge of foundation

7. For small buildings of light frame construction, what is the least size of sill you may use?

a. 2″ x 4″
b. 2″ x 6″
c. 2″ x 8″
d. 2″ x 10″

8. You are constructing a T-sill to support 2″ x 4″ studs and 2″ x 6″ joists. The header will be nailed to the end of the joists. What size material will you use for the sill plate?

a. 2″ x 12″
b. 2″ x 10″
c. 2″ x 8″
d. 2″ x 6″

9. You are constructing a building 40 feet long by 20 feet wide. The plans require that a one-piece girder run the length of the building. You would support this girder at both ends by the foundation, and by columns at a minimum of

a. five intermediate points

b. four intermediate points

c. three intermediate points

d. two intermediate points

10. The floor of an 18′ x 26′ building has a dead load and a live of 50 and 30 pounds per square foot, respectively. The floor is supported by the foundation wall and a girder which is located 12 feet from one end of the building. The total load in pounds on the girder is

a. 20,160
b. 18,720
c. 17,280
d. 15,840

11. Floor joists in frame buildings should extend from wall to wall, and have a bearing surface of at least

a. 3 inches on each end

b. 4 inches on each end

c. 3 inches on exterior wall and 4 inches on girder

d. 6 inches on exterior wall and 6 inches on girder

12. A box, or L-sill, provides the advantage of a single sill, a firestop, and a solid bearing surface for nailing the

a. subfloor
b. headers
c. girder
d. cross bracing

13. A floor joist must have a hole for a 1-inch pipe. How would you prevent significant loss of strength in the joist?

a. use a double joist

b. make hole ¼ of depth from top edge

c. make hole ¼ of depth from bottom edge

d. put hole in middle of the joist

14. When you are framing a ceiling opening for a 24″ x 24″ chimney, how long do you make the length of the headers?

a. 20¾″
b. 24″
c. 27⅛″
d. 28″

15. You are at the building site, ready to start the building layout. If the ground is not level, where do you place the first batter board?



111

a. lowest point

b. any point

c. highest point

d. first corner

16. When would you use the wall-type foundation?

a. for temporary construction

b. to support light building loads

c. for permanent structure

d. when structure is at ground level

17. When you pour concrete for wall footings, what would you use to assure proper thickness?

a. grade stakes at building corners

b. grade stakes between the forms

c. wooden footing forms

d. screeds

18. In standard permanent construction, what material would you select for the sills?

a. No. 1 common lumber

b. No. 2 common lumber

c. No. 3 common lumber

d. any lumber of great strength

19. A girder that is 3 inches wide and 16 inches deep can carry how much more weight than a girder 3 inches wide and 8 inches deep?

a. 6 times more

b. 5 times more

c. 4 times more

d. 3 times more

20. You must splice lumber while making a built-up girder. What is the maximum number of joists that you allow over a span between footings?

a. 1

b. 2

c. 3

d. 4

# LESSON 2

## EXTERIOR FRAMING

CREDIT HOURS ____________________3

TEXT ASSIGNMENT ____________________Study chapter 2, Memorandum 532.

LESSON OBJECTIVE ____________________To teach you how to make a building layout and do floor framing, to include purpose and use of sills, girders, joists and bridging.

---

### EXERCISES

**Requirement:** Solve the following multiple-choice exercises:

1. What is the thickness of the material that you must use in spacing 2 x 4's that are placed vertically as double headers?

a. 3/16 inch
c. ⅜ inch
b. ¼ inch
d. ½ inch

2. In a weight-bearing wall, what is the safe maximum length in feet of an unbraced 2 x 4 inch stud?

a. 4
c. 7
b. 6
d. 8

3. Sheathing prevents the movement of air through the walls of buildings and deadens external sounds. What is another of its characteristics?

a. has insulating quality
b. gives decorative finish
c. provides extra weight
d. adds rough texture for base siding

4. A horizontal sliding door drags on the floor. What is your first action to correct this?

a. trim the door
b. raise channel mounting bolts
c. lower roller assembly mounting bolts
d. adjust the bolt of the roller assembly

5. What are the two main parts of a window?

a. sash and the glass
b. frame and the glass
c. sash and the frame
d. jamb and the casing

6. The girders used in porch construction run perpendicular to the

a. subfloor and joists
b. floor boards
c. joists and floor boards
d. wall of the building

7. Which of the following woods would you select to make window screens?

a. oak

b. gum

c. northern white pine

d. southern yellow pine

8. Plastic siding materials are often used for decorative purposes because they are

a. less expensive

b. exceptionally strong

c. available in many shapes and colors

d. easily installed with siding nails

9. What weight building felt would you usually use under siding?

a. 90 pounds per 100 square feet

b. 60 pounds per 100 square feet

c. 30 pounds per 100 square feet

d. 15 pounds per 100 square feet

10. You must improve the seal between a door and the frame. Where would you install metal weather stripping?

a. side of the jamb

b. back of the casing

c. side of the door

d. edge of the door

11. What is usually the maximum rise in inches per step on exterior porch steps?

a. 10 c. 6

b. 8 d. 4

12. You must replace part of a piece of siding. Where on the old siding board would you make the cut?

a. most accessible spot

b. between the studs, if possible

c. next to the splice or over it

d. so joint would be on center of stud

13. You have selected grade 1 caulking compound to apply with a gun to fill and seal joints. Why did you make this selection?

a. compound hardens rapidly

b. great color selections

c. compound has consistency of putty

d. less time neded than knife

14. Glass measuring 27" x 27" must be replaced in 100 windows. If the sash is rabbetted ½ inch, how many gallons of putty will you need to bed and face glaze the glass?

a. six c. four

b. five d. three

15. Which of the following is unimportant when you choose wood for exterior walls?

a. grain patterns

b. paint-holding quality

c. lumber grade

d. decay resistance

16. You must select girders for a porch. What would be the maximum weight per square foot that you figure the girders would carry?

a. 60 pounds c. 40 pounds

b. 50 pounds d. 30 pounds

17. The plans for a porch specify a total floor slope of 2 inches. What does this mean to you?

a. the porch extends 8 feet from the building

b. footing for the porch must be about 8 feet from the building

115

c. the porch is small enough to be classified as a stoop

d. roof rafters must be 7 feet long to permit 12 inch cornice

18. You are building a general type porch with footings 18 inches square and 8 inches thick. What is the maximum distance in feet that you would space these footings?

a. 10 c. 6

b. 8 d. 4

19. What can you do to help prevent porch stair treads from warping?

a. plow furrows on underside of treads

b. use material at least 1¾ inches thick

c. use tongue and groove material

d. slope the treads ¾ inch

20. Corrugated metal sheets are available in several lengths. What is the usual width in inches?

a. 28 c. 24

b. 26 d. 22

# LESSON 3

## ROOF FRAMING AND MATERIALS

CREDIT HOURS ........................ 3

TEXT ASSIGNMENT ........................ Study chapter 3 of Memorandum 532.

LESSON OBJECTIVE ........................ To teach you the methods and procedures for constructing roof frames and coverings, to include selection of materials and use of tools.

---

### EXERCISES

**Requirement:** Solve the following multiple-choice exercises:

1. What are the common spacings of rafters in inches?

a. 16 to 24 c. 16 to 20

b. 18 to 24 d. 18 to 20

2. When nailing rolled roofing, the nails should be spaced?

a. 6 inches from the edge and 4 inches apart

b. 2 inches from the edge and 6 inches apart

c. 6 inches apart and 4 inches from the edge

d. 4 inches apart and 2 inches from the edge

3. Roof framing members used to bridge in between or connect trusses are called?

a. rafters c. purlins

b. webs d. chords

4. When you cut a bird's mouth on a rafter, what is the common depth of the cut in inches?

a. 3⅝

b. 1⅝

c. ½ width of rafter

d. ⅓ width of rafter

5. What would you call a built-up roof containing five plies of felt?

a. 10-year roof c. 15-year roof

b. 20-year roof d. 25-year roof

6. Which of the following rafters touches neither the ridge of the roof nor the rafter plate?

a. cripple c. jack

b. valley d. hip

7. Why would you use layers of felt in a built-up roof?

a. to reflect heat

b. to hold the bitumen in place

c. to deflect water

d. to have waterproof layer between coats of bitumen

8. Roofs that have no slope are covered with saturated felt and

a. coal tar pitch

b. asphalt

c. flat slate

d. asbestos-cement

9. Standing-seam metal roofing with unsoldered seams should not be used on a roof having a slope less than

a. 12 inches per foot

b. 7 inches per foot

c. 5 inches per foot

d. 3 inches per foot

10. The minimum slope of a roof deck to be surfaced with asbestos-cement shingles should be

a. 6 inches per foot

b. 5 inches per foot

c. 4 inches per foot

d. 3 inches per foot

11. How do you usually lay corrugated asbestos-cement sheets?

a. over open-wood or metal frames

b. on rafters without decking

c. with solid decking and felt

d. on slat type decking

12. What is the maximum exposure in inches that you would allow to asphalt shingles that measure 10″ to 36″?

a. 8 c. 4

b. 6 d. 3

13. How would you repair small tears in composition roll roofing?

a. nail and coat with bitumen

b. nail coated piece of roofing beneath the tear

c. nail patch over tear and coat with bitumen

d. place bitumen beneath tear and renail

14. An asphalt shingle roof has received minor hail damage. How do you repair it?

a. remove broken shingles and replace with new

b. break all old and brittle shingles and repair them

c. spray surface with asphalt paint

d. cover exposed felt spots with coating of plastic cement

15. You are repairing a roof made of corrugated asbestos-cement sheets, but you cannot use the original method of framing. What do you use to install the new sheets?

a. lead head nails

b. screws and washers

c. nails and metal strips

d. toggle bolts and washers

16. A tile roof in otherwise satisfactory condition leaks. What is the most likely reason for this?

a. fasteners are too loose

b. nail holes are too large

c. underlayment has disintegrated

d. lack of caulking in lap joints

17. Which of the following choices names two types of valley flashing materials?

118

a. open and closed

b. rolled roofing and sheet metal

c. copper, and zinc-coated iron

d. lap joint and turned-up flange

18. What causes the most frequent repair on a promenade tile roof?

a. replacing broken tiles

b. replacing cement in the joints

c. replacing fasteners on old tiles

d. using too few expansion joints

19. You discovered a truss bolt that jiggles loosely when you tap it. What do you do?

a. tighten the nut

b. use shorter bolt

c. add washers and tighten nut

d. replace it with bolt of larger diameter

20. How many pounds gravel would you need to repair an area 10 x 50 feet on a mineral surfaced built-up roof?

a. 2000
b. 1600
c. 800
d. 400

# LESSON 4

## INTERIOR FRAMING

CREDIT HOURS ---------------------------------3

TEXT ASSIGNMENT ---------------------------Study Chapter 4 of Memorandum 532.

LESSON OBJECTIVE -------------------------To teach you the methods for installing and maintaining interior walls and ceilings, doors and window trims, and floors and stairways.

---

### EXERCISES

**Requirement:** Solve the following multiple-choice exercises.

1. You check seasoning and color in selecting wood wall coverings. What else do you consider?

a. knots and grain

b. grain and finish

c. knots and durability

d. grain and durability

2. In most windows, what does the interior window trim consist of?

a. trim, stool, and apron

b. casing, apron, and trim

c. casing, sill, stool, and apron

d. trim, sill, and stool

3. You are replacing a panel in a door, and you have cut the exterior grade plywood to fit the panel hole. How much clearance do you allow, in width and length, for the new panel?

a. 1/16 inch

b. ⅛ inch

c. 3/16 inch

d. ¼ inch

4. When installing hinges on doors, where would you place them?

a. 12 inches from top and 12 inches from bottom

b. 9 inches from top and 11 inches from bottom

c. 7 inches from top and 11 inches from bottom

d. 5 inches from top and 7 inches from bottom

5. You have a bolt that does not hit the striker plate properly. You decide to file a bigger hole in the striker plate. What tolerance do you have in this filing before you must remove the striker plate and then raise or lower it to match the bolt?

a. ¼ inch

b. 3/16 inch

c. ⅛ inch

d. 1/16 inch

6. If you use plywood as the base for nonwood floor covering. What minimum thickness of plywood do you select and how do you lay it?

a. ⅜ inch thick, 4 ply, with moisture-resistant glue

b. ⅜ inch thick, 3 ply, with moisture-resistant glue

c. ¼ inch thick, 4 ply, with moisture-resistant glue

d. ¼ inch thick, 3 ply, with moisture-resistant glue

7. Why are double plates used on both ends of the studs of a partition wall?

a. add strength for floor and ceiling joints

b. extra support to the wall for the vented stack

c. more strength for the wainscot

d. additional nailing surface for the ends of wall panels

8. You are constructing a stairway that will be suitable for most persons (all ages) to climb. Which of the following would accomplish this?

a. 10-inch tread, 7-inch riser

b. 8-inch tread, 7-inch riser

c. 10-inch tread, 5-inch riser

d. 10-inch tread, 9-inch riser

9. In laying out stringers, you subtracted one tread thickness from the height of the first riser. Why did you do this?

a. compensate for tread thickness on the first step

b. so that stringers could be notched to fit ledgerboard

c. to permit use of kickplate at bottom of stringers

d. compensate for slope of stringers in stairway

10. To get best results, when would you place tile on asphalt adhesive?

a. just before gloss disappears

b. after gloss is gone, and surface is tacky and appears dry

c. while surface is wet and tacky

d. after gloss is gone and surface is quite dry

11. On what part of the wall would you place the picture mold?

a. above the window and door casings

b. 12 to 16 inches from the floor

c. 48 inches from the floor

d. near the ceiling

12. How many square feet are in a floor requiring 12 standard tiles in length and 8 standard tiles in width?

a. 108 c. 72

b. 96 d. 54

13. What is the name given to floors of tile-size wooden blocks?

a. wainscot c. square tile

b. parquet d. strip tile

14. The desirable number of steps in a flight of stairs is determined by dividing the total rise by

a. 10 c. 8

b. 9 d. 7

15. Which of these methods would you use to loosen and remove an asphalt tile?

a. heat and then use hammer and chisel

b. heat and lift out with putty knife

c. soak with water and rake out with hoe

d. apply ice and chip out with hammer and cold chisel

16. You have decided to place felt on the subfloor. What is the best way to do this?

a. cut felt for entire room before any of it is pasted down

b. square the ends and join them at lap joint

c. overlap the felt on all sides

d. cut the felt and make a lap joint

17. How many inches of head room would you allow for a normal stairway?

a. 90 c. 80

b. 86 d. 72

18. You are making the riser height 7 inches on the stairway that you are building. How wide will you make the tread in inches?

a. 7 to 9 c. 17 to 18

b. 10 to 11 d. 20 to 22

19. How would you fasten nonslip nosings to stair treads?

a. nails

b. screws

c. adhesive paste

d. nonresistant glue

20. A landing should be placed in the middle of a stairway when the number of steps exceeds?

a. 20 c. 15

b. 18 d. 14

21



1 3 58.996— AG—Ft Belvoir

122

# CORRESPONDENCE COURSE OF U. S. ARMY ENGINEER SCHOOL

SUBCOURSE 532-0 . . . . . . . . . . . . . . . Carpentry II (Frame Construction).
LESSON 1 . . . . . . . . . . . . . . . . . . . . . . Building layout and floor framing.

## SOLUTIONS

Each exercise has a weight of 5. All references are to Memorandum 532.

1. *d* (par 2-13)
2. *a* (par 1-14)
3. *a* (par 1-12)
4. *c* (par 2-25)
5. *b* (par 2-6)
6. *a* (par 3-10)
7. *b* (par 3-8)
8. *b* (par 3-6)
9. *c* (par 3-42)
10. *a* (par 3-32)
11. *b* (par 3-46)
12. *a* (par 3-7)
13. *d* (par 3-62)
14. *d* (par 3-61)
15. *c* (par 1-6)
16. *c* (par 2-2)
17. *b* (par 2-19)
18. *a* (par 3-9)
19. *c* (par 3-23)
20. *a* (par 3-36)

For further explanation, see Discussion.

**All concerned will be careful that neither this solution nor information concerning the same comes into the possession of students or prospective students who have not completed the work to which it pertains.**

EDITION 0 (NRI 011)



This copy is a reprint which includes Solution Change No. 1, dated 14 June 1973.

# DISCUSSION

**Exercise:**

1. The full unit form permits **a long wall to be built in sections (d)** using the same form for the different sections.

2. To check whether the building is square, you should check the corners by **measuring the diagonals of the building (a).** If the diagonals are not the same length, the building is not square.

3. This rule is followed by laying out a triangle with the three-foot leg along the base line, the four-foot leg at right angles with the base line, and the five-foot leg connecting the ends of the other two legs. The perpendicular leg is extended to the opposite side to locate the third corner, which is where this line and the opposite side line cross (a).

4. Supporters and stakes are usually **2 x 4's (c)** of the kind and grade of lumber used for wall framing.

5. The footings may be poured prior to or with the rest of the foundation. When the footing is poured separately. Shifting of the foundation is prevented by **keyways or metal pins (b).**

6. If the outside surface of the wall is stuccoed, the outside edge of the sill should be placed **even with the outside edge of the foundation wall (a).** When siding is used instead of stucco, the siding provides the overlap below the sill.

7. Sizes of sills vary for the various types of construction. For small buildings of light-frame construction, **a 2" x 6" sill (b)** is large enough under most conditions.

8. If the header is spiked against the joists, the sill plate would be **2" x 10" (b).**

9. When locating columns, it is well to avoid spans of more than 10 feet between columns that are to support the girder; therefore **three intermediate points (c)** should be used. Figure 22 shows a good arrangement of the girder and supporting columns for a building 40 feet long.

10. According to par 3-32:

26′ = length of building

− 12′ = distance of girder from one end

14′ = length of girder

$\frac{1}{2} \times 12 + \frac{1}{2} \times 14 = 6 + 7 = 13'$ = floor length loading girder

$13 \times 18 = 234$ sq ft girder load area

$234 \times 80$ (total load per sq ft) = 18,720 (b) total pounds on girder

11. Floor or ceiling joists should be long enough to give a sufficient bearing to each end. In a frame building, a minimum of 3 inches is usually satisfactory for ceiling joists, but **at least 4 inches** (b) on each end is preferred for floor joists.

12. The L-sill is generally used in the platform type of framing. It provides solid bearing upon which to nail the **subfloor** (a).

13. Small holes such as a hole for a 1" pipe, drilled near the **center of a joist** (d), will not decrease the strength to any great extent, because the upper and lower fibers have not been cut.

14. The trimmers and headers for chimneys should be located two inches from each surface of the chimney to prevent the heat of the chimney from causing a fire. Therefore: 24" + 2" + 2" = 28" (d).

15. The first batter board erected should be located at the **highest point** (c) of the build-site. If the ground is relatively level, the first batter board can be erected at any point.

16. Wall-type foundations are solid and usually form a continuous support for the external walls of a building. You use the wall-type where heavy building loads are to be supported or when the structure is of **permanent type construction** (c).

17. The wall forms will be anchored with **stakes**, and they are driven **between the forms** to assure proper thickness (b) and easier leveling. Figure 8 illustrates this method.

18. Material for sills may be of practically any locally available lumber, but for standard permanent construction **No. 1 common lumber** (a) should be used.

19. When depth of girder is doubled, the safe load is increased **four times** (c). In other words, a girder 3" wide and 16" deep will bear 4 times as much weight as a girder 3" wide and 8" deep.

20. To make a built-up girder, select straight lumber free from knots and other defects. The length of the stock should be great enough so that no more than **one joint** (a) will occur over the span between footings.

# CORRESPONDENCE COURSE OF U. S. ARMY ENGINEER SCHOOL

SUBCOURSE 532-0 . . . . . . . . . . . . . . . . Carpentry II (Frame Construction).
LESSON 2 . . . . . . . . . . . . . . . . . . . . . Exterior Framing.

## SOLUTIONS

Each exercise has a weight of 5. All references are to Memorandum 532.

1. *c* (par 6-6)
2. *b* (par 4-6)
3. *a* (par 5-8)
4. *d* (par 6-25)
5. *c* (par 6-46)
6. *d* (figure 77)
7. *c* (par 6-82)
8. *c* (par 7-19)
9. *d* (par 7-5)
10. *a* (par 6-43)
11. *b* (par 8-16)
12. *d* (par 7-38)
13. *d* (par 7-34)
14. *a* (par 6-62)
15. *a* (par 7-2)
16. *b* (par 8-7)
17. *a* (par 8-6)
18. *a* (par 8-3)
19. *a* (par 8-17)
20. *b* (par 7-18)

For further explanation, see Discussion.

# DISCUSSION

**Exercise:**

1. Headers are usually made of stud material and may be installed flat or vertically. Vertically installed headers are stronger but must be spaced with **⅜-inch** (c) material.

2. It is well to remember that if the height of the stud as a column or post is more than fifty times its unbraced dimension, it is unsafe. To keep within this ratio, an ordinary 2 x 4 standing unbraced should not be more than about 6 (b) feet in height, about fifty times 1⅝″.

3. Sheathing serves to prevent movement of air through walls of buildings and in this way **insulates** or deadens external sound (a).

4. The location of the channels determines the approximate clearance between the bottom of the door and the floor. You can, however, make final vertical **adjustments on the bolt of the roller assembly** (d).

5. Like doors, windows have two main parts — the **frame and the sash** (c). The window frame finishes the wall opening and holds the sash, which contains the glass and which may be moved for opening and closing.

6. Girders for porches are required as part of porch framing to carry the porch joists. They run **perpendicular to the building wall** (d) as shown in figure 77.

7. Of the choices offered, **northern white pine** (c) ¾ to 1⅛ inches thick would be used for screens and screen repairs.

8. Vinyl or other plastic materials are easily molded during manufacture into a **variety of shapes** (c). A wide selection of **colors** is available also.

9. Building paper is a felt-type material impregnated with tar or asphalt. It is sometimes referred to as building felt. Different weights are available, but **15-pound paper (15 pounds per 100 sq ft)** (d) is usually used under the siding.

10. Weather stripping of several different types is available; felt and rubber materials are soft or spongy and are fastened to the door jamb. Install metal weather stripping **on the side of the jamb** (a).

11. The rise per step should not be more than **8 inches** (b). There are times when 5½ and 6 inch risers are used, but from 6½ to 7 inches make the most comfortable step to travel.

12. When only a part of a board is to be replaced, you cut the board with a wood chisel so that the joint will **be on the center of a stud** (d). This will provide a nailing surface for the ends of the old and new boards.

13. Gun application of grade 1 is recommended for general use, since it is easy to apply, is economical, and takes about **one-third the time** (d) required for knife application.

14. One gallon of putty will normally bed and face glaze approximately 150 linear feet of ½ inch rabbet.

| | |
|---|---|
| 27″ | |
| × 4 | sides to each window |
| 108″ | = liner inches in one window |
| × 100 | windows |
| 10,800″ | = linear inches in the 100 windows |
| 900′ | = linear feet in the 100 windows |
| 150′ | = linear feet from one gallon |
| 900′ ÷ 150′ | = **six (a)** gallons needed for the 100 windows. |

15. Wood is ordinarily used at least for the trim. In choosing the wood, you should consider its paint-holding quality, the grade, and its decay resistance. The **grain patterns (a)** are unimportant in selecting wood for the finish.

16. Porch girders carry only the weight of the porch floor and joists. Accordingly, there is no need to consider any load other than 40 **pounds** per square foot live load **plus 10 pounds (b)** as a good average for the dead load.

17. To provide adequate drainage, a porch floor should slope ¼ inch per foot away from the wall of the building. A slope of 2 inches (8/4) would indicate **the porch extends 8 feet from building (a).**

18. The general type of front or side porch usually requires concrete footings 18 inches square and 8 inches thick. Such footings should not be spaced more than **10 feet (a)** apart.

19. Although it is not a common practice, it is practical **to plow furrows on the underside of treads (a)** at intervals of 3 or 4 inches and about ¼ inch deep. This will help prevent warping and will allow the tread to lie flat when securely nailed to the carriage.

20. Corrugated and V-crimped sheets are usually **26 inches wide (b)** and in lengths of 6 to 12 feet. They can be installed horizontally, but more often they are placed vertically.

128

# CORRESPONDENCE COURSE OF U. S. ARMY ENGINEER SCHOOL

SUBCOURSE 532-0 . . . . . . . . . . . . . . . . . Carpentry II (Frame Construction).
LESSON 3 . . . . . . . . . . . . . . . . . . . . . Roof framing and materials.

## SOLUTIONS

Each exercise has a weight of 5. All references are to Memorandum 532.

1. *a* (par 9-49)
2. *b* (par 10-9)
3. *c* (par 9-67)
4. *b* (par 9-44)
5. *b* (par 10-18)
6. *a* (par 9-30)
7. *b* (par 10-18)
8. *a* (par 10-17)
9. *d* (par 10-25)
10. *c* (par 10-31)
11. *a* (par 10-33)
12. *c* (par 10-13)
13. *b* (par 10-52)
14. *d* (par 10-62)
15. *d* (par 10-17)
16. *c* (par 10-76)
17. *b* (par 10-80)
18. *d* (par 10-75)
19. *c* (par 10-42)
20. *a* (pars 10-13, 10-64)

For further explanation, see Discussion.

## DISCUSSION

**Exercise:**

1. Spacing is determined by the stiffness of sheathing between rafters, by the weight of the roof, and by the rafter span. Spacing from 16 to 24 (a) inches is common.

2. Each roofing strip must have an overlap which must be properly cemented. Nails must be **six inches apart and 2 inches from the overlap edge** (b).

3. When trusses are used to support a roof, they are often placed at intervals from 10 to 20 feet. In these instances, **purlins** (c) are used to bridge in between trusses.

4. The cuts may be any depth which is not greater than one-half the width of the rafter material. The common depth is 1⅝ (b) inches.

5. Built-up roofs are designated by the number of plies they contain. A **20-year roof** (b) usually contains 5 plies, 15-year roof has 4 layers, and a ten-year roof has 3 layers.

6. A **cripple** (a) jack rafter extends from a hip to a valley rafter. This rafter is also part of a common rafter but touches neither the ridge of the roof nor the rafter plate.

7. Layers of felt in a built-up roof do not materially waterproof a roof. The layers of felt function primarily **to hold the layers of bitumen in place** (b).

8. The bitumen that is used for coating the saturated felts may be asphalt or coal tar pitch. This **coal tar pitch** (a) is especially adaptable for "dead level" built-up roofs on which water tends to stand.

9. Because standing seams are unsoldered, they are not used on roofs with slopes of **less than 3 inches per foot** (d) and should preferably be used with slopes of 4 or more inches per foot.

10. Asbestos-cement shingles are used on roofs with at least a **4 inch rise per foot** (c) run; asbestos-cement sheets are used on slopes of 3 or more inches per foot.

11. Corrugated asbestos-cement sheets are normally laid over **open wood or steel framing** (a). These sheets are fastened to horizontal purlins that are fastened to the top of rafters or trusses.

12. There are two types of asphalt-strip shingles. One is a standard-weight four-tab 10″ x 36″ intended for a **4-inch** (c) maximum exposure. The other is a thick-butt, three-tab, 12″ x 36″ for a 5-inch maximum exposure.

13. Small breaks and nail holes may be repaired by applying asphalt plastic cement, but small damaged areas and tears are repaired by **placing a coated new piece of roofing below the damaged area** (b).

14. Minor damage occurs when the nail knocks the granules off the tabs to expose black spots of felt but does not break the shingle. **Cover the exposed spots with a coating of plastic cement** (d) to protect the shingle.

130

15. When you cannot use the same method of fastening, then you may substitute **toggle bolts with lead or plastic washers** (d). Make a hole in a ridge that will allow the bolt to pass through easily.

16. After long periods of service, tile roofs in otherwise satsifactory condition may leak because of the **disintegration of the 30-pound felt underlayment** (c).

17. When two sloping roofs intersect, some type of flashing must be used. A hasty valley flashing for temporary buildings is made of two thicknesses of **rolled roofing**. A valley flashing of **sheet metal** (b) is recommended on permanent buildings.

18. The most frequent repair work on a promenade tile roof is that caused by **using too few expansion joints** (d) between the promenade tiles or by permitting the expansion joints to become filled with solids.

19. When bolts that are too long are used, it is impossible to draw a nut up tight to obtain a firm connection. **Adding additional washers** (c) will take up the space and allow the bolt to be tightened correctly.

20. A square is the amount of roofing material needed to cover an area of 100 square feet. Gravel is embedded in the hot bitumen at the rate of 400 pounds per square.

$10' \times 50' = 500$ sq ft = area to repair

$500 \div 100 = 5$ = number of squares

$400$ = pounds of gravel required per square

$5 \times 400 = 2000$ **(a)** = pounds of gravel needed.

# CORRESPONDENCE COURSE OF U. S. ARMY ENGINEER SCHOOL

SUBCOURSE 532-0 . . . . . . . . . . . . . . . Carpentry II (Frame Construction).
LESSON 4 . . . . . . . . . . . . . . . . . . . . . . Interior Framing.

## SOLUTIONS

Each exercise has a weight of 5. All references are to Memorandum 532.

1. *a* (par 11-23)
2. *c* (par 12-23)
3. *b* (par 12-22)
4. *c* (par 12-8)
5. *c* (par 12-16)
6. *b* (par 13-21)
7. *d* (par 11-2)
8. *a* (pars 14-8, 14-25)
9. *a* (par 14-17)
10. *b* (par 13-40)
11. *d* (par 11-30)
12. *d* (pars 13-28, 29, 30)
13. *b* (par 13-10)
14. *d* (par 14-12)
15. *b* (par 13-48)
16. *a* (par 13-20)
17. *a* (par 14-7)
18. *b* (par 14-8)
19. *b* (par 14-29)
20. *c* (par 14-3)

For further explanation, see Discussion.

# DISCUSSION

**Exercise:**

1. The wood used in wall covering is usually selected because of its desirable color, the number and kind of **knots, and its grain** (a).

2. Interior trim of double-hung windows consists of the **casing, sill, stool and apron** (c). See figure 135.

3. You can use a wood chisel to remove the panel molding. Cut a piece of plywood 3/16 or 1/4 inch thick and make it **1/8 inch** (b) undersize in width and length to replace the old panel.

4. When the door is properly positioned, it should be firmly wedged and the hinge locations marked on both the stile and the jamb **7 inches from the top** of door and **11 inches from bottom** (c) of door.

5. If the bolt strikes squarely on the plate and requires removal of **as much as 1/8 inch** (c) of the metal, remove the striker plate and raise or lower it to match the height of the bolt.

6. Plywood underlayment should not be less than **3/8 inch thick, 3 ply, with moisture-resistant** glue (b).

7. Double plates are used on both ends of the studs to provide an additional **nailing surface for the ends of wall panels** (d).

8. If the **riser height is 7 inches,** which is the most desirable height, then the **tread width would be 10 inches** (a). The slope of a stairway should be between 20° and 50° from horizontal, but 30° to 35° is preferred, for this slope is easier for most individuals to climb.

9. The square is held as shown in figure 152, and then the thickness of the first tread is subtracted from the height of the first riser. This subtraction is necessary to **compensate for tread thickness** (a).

10. You should allow the adhesive to dry until **gloss is gone and surface is tacky and appears dry** (b). Tiles placed on adhesive that is still wet will prevent adhesive from drying and tiles will slip. Tiles placed on adhesive that is too dry will not stick securely and will give off a hollow sound when they are walked upon.

11. The picture mold is placed against the wall **near the ceiling** (d), usually up against the ceiling. Some builders prefer to lower it to 12 or 16 inches below the ceiling.

12. Standard tile is 9″ x 9″

$12 \times 9'' = 108'' = 9' =$ length of floor

$8 \times 9'' = 72'' = 6' =$ width of floor

$9' \times 6' =$ **54** (d) square feet floor area

13. Wood floors of tile-size wood blocks are parquet (b) floors. Tongue-and-groove strips of wood are assembled to form square tile. Some of these blocks are glued together, and others have several metal straps across the back.

14. The number of risers on a stringer is determined by dividing the total rise by the riser height. **Seven (d) inches is the preferred riser height.**

15. Single tile may be removed by chipping out, but **applying heat to tile will loosen it** from the cement **so that it can be lifted out with a putty knife (b).**

16. The edges should never be overlapped. Where two strips of felt join, they should be butted together. For best results, **the felt is cut for an entire room before any of it is pasted down (a).**

17. Head room is the clearance measured vertically from the top of a tread to the underside of the stair or ceiling above. **Seven and one-half feet (a)** clearance is satisfactory for head room on normal stairways.

18. One tread width and one riser height added together should be between 17 and 18 inches. For example, if the riser height is 7 inches (the most desirable height) the tread width would be between **10 and 11 (b)** inches.

19. Special care must be taken in setting the nonslip nosings on worn treads. Commercial tread nosings may be used to rebuild treads. **Screws (b)** are preferred for fastening the nosings in place because they do not work loose as easily as nails.

20. A stairway with a long flight consisting of more than **15 (c)** steps is tiring because it offers no opportunity for a pause in ascent. For this reason a landing should be introduced, usually at the **half-way point.**

134

Essayons

# MEMORANDUM 532-0

# CARPENTRY II
## (FRAME STRUCTURES)

3-8

# U.S. ARMY ENGINEER SCHOOL

FORT BELVOIR, VIRGINIA

MOS: 51B20

EDITION 0 (NRI 011)

7

34

135

## CONTENTS

# Building Layout and Floor Framing

THE CREATION of a building begins on the drawing board. To make it a reality, the building plans must be given to the carpentry specialists who, in turn, perform the necessary tasks until the building emerges as a completed structure.

2. A building or structure is no more stable than the ground on which it is located and no stronger or more rigid than the foundation on which it stands. As a carpentry specialist, you may be required to construct a building or structure of some type. To help you do this, we will give you a step-by-step procedure for laying out a building.

3. The term "laying out" means the process of locating and fixing reference lines which define the position of the foundation and outside walls of a building or structure to be erected.

4. This chapter will introduce you to the procedures to be taken in laying out a building and constructing the floor framing. You may ask, "What are the steps in laying out a building?" Well, study this chapter carefully and you can acquire the necessary knowledge to perform these tasks.

## 1. Building Layout

1-1. You have learned in Volume 1 to determine the detailed construction features of buildings or structures from working drawings and prints. Now we are ready to discuss the actual job of constructing a building.

1-2. The first and probably the most important task is the layout work. During layout, you will establish the exact location and outside dimensions of the building.

1-3. Before constructing a building, you should make a careful study of the building site. Some of the items you must check when making the study are soil characteristics, natural drainage probabilities, and surrounding structures. If possible, buildings should be located on relatively high ground. This will minimize the possibility of water seepage at the foundation.

1-4. **Building Lines.** After the location and alinement of the building have been determined, you are ready to stake out the building. Staking out is a method of marking the corner locations so that the exact boundaries (building lines) can be determined. You will usually lay out and stake out small buildings, but an engineer will stake out large buildings or structures. If you don't have a transit to accurately measure the angles, you can measure them satisfactorily with a tape measure. You should use a steel tape if available. Accuracy cannot be overemphasized. because a mistake in either laying out or staking out the building could be a constant source of trouble as the building progresses. The outside surface of the foundation walls is the building line, and the edge of the excavation is the excavation line. It is important that these lines be accurate and permanently marked. The marking is done with a tightly stretched cord, approximately ⅛ inch in diameter.

1-5. **Batter Boards.** It is customary to construct batter boards, as shown in figure 1, to hold the cord. Batter boards are preferred because they remain in place during the excavation. The approximate location of the building must be determined and the batter boards positioned before an accurate layout can be made. One of these boards should be placed about 4 feet outside of each corner location.

1-6. The blueprint will indicate the size of the building and specify how far it should be placed from some stationary reference line. With this information, it is possible to properly locate the batter boards. The first batter board erected should be located at the highest point of the building site. If the ground is relatively level, the first batter board can be erected at any point. Regardless of which batter board is first erected, the crossbars of all batter boards must be level with each other.

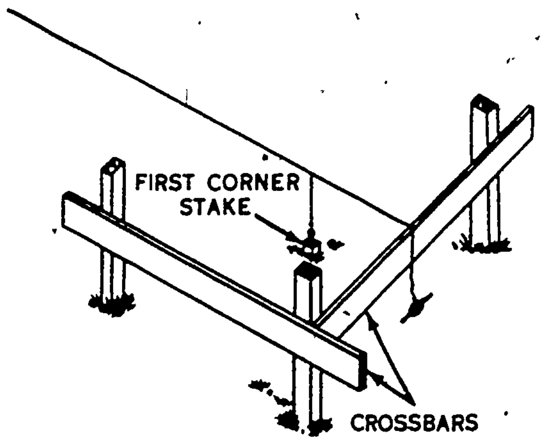



Figure 1. Three-post batter board.

1-7. Prepare the batter boards with posts of sufficient length to serve as secure anchors. They must maintain a reliable reference/for location and height until construction of the foundation is completed. Therefore, they should be strong enough to hold a tightly stretched cord and to absorb occasional accidental bumps without moving.

1-8. **Layout.** When the batter boards are in place, the exact corner points can be located. The location of the first corner can be determined by measuring from the reference line shown on the blueprint. When this location has been determined, it should be marked by driving a stake into the ground. A small finishing nail should be driven flush with the top to mark the exact location of the corner. A line should be stretched between the first and second batter boards, parallel to the reference line. This line must pass directly above the nail in the first corner stake, and will be referred to as the base line. You can check the location of the base line by measuring the distance to the reference line at both ends.

1-9. *Leveling the lines.* To level the base line, use a line level. The line level consists of a bubble tube set into a metal case which has a hook at each end to permit it to be hung on a line. Figure 2 illustrates a line level. A line level is particularly useful when leveling between two points that are too far apart to use the carpenter's level and straightedge. To use the line level:

- Stretch a line between the two points which are to be checked for level.
- Hang the line level on the line near the center and see if the bubble is in the middle of the tube. If not, lower or raise the line until the bubble rests in the center of the tube.
- Check the level by turning it end for end, and recheck the line. This is done to check the accuracy of the level. Sometimes the hooks at the end of the level will get bent, causing the level to read untrue.
- Keep the level in a box when not in use, as it is a delicate instrument. This box keeps the bubble from being broken and the hooks from being bent.

1-10. *Locating the other corners.* The length of the side of the building, which lies between the first and second corners, should be measured along the base line from a point directly above the nail in the first corner stake. Another stake should be driven to mark the second corner and a nail driven in its top to mark the exact corner location.

1-11. You can check the opposite side line of the building by fastening a line between the third and fourth batter boards. This line is made parallel to the base line in the same manner that the base line was made parallel to the reference line.

1-12. The third corner is located by placing a cord between the second and third batter boards. You can make this line perpendicular by any one of several methods. One method, the "three, four, five" rule, is accomplished by laying a triangle with one 3-foot leg along the base line, one 4-foot leg at right angles with the base line, and a 5-foot leg connecting the ends of the other two legs. The triangle must be so located that the 3-foot leg and the 4-foot leg join exactly over the corner stake nail head. For greater accuracy, a larger triangle may be used. Regardless of the size of the triangle, one leg must be perpendicular to the base line. The perpendicular leg must be extended across the building layout to the opposite side in order to locate the third corner. A third corner stake is

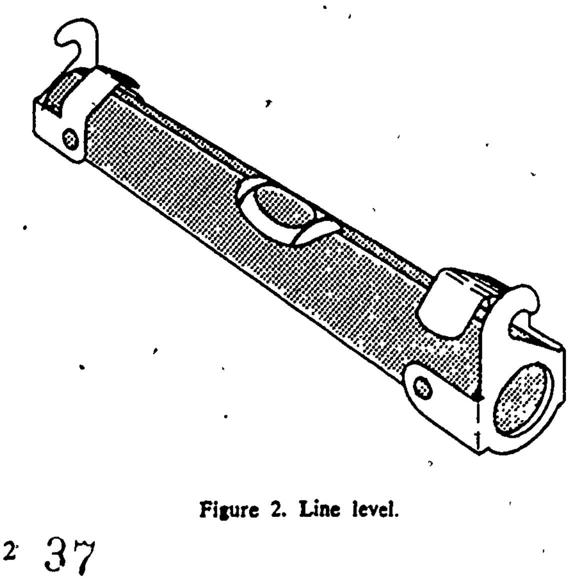


Figure 2. Line level.

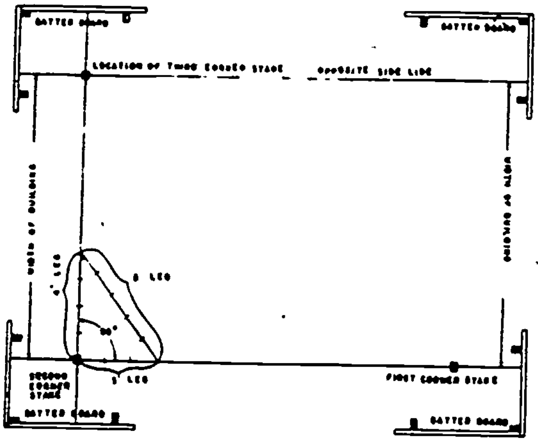


Figure 3. Layout procedure.

placed where this line and the opposite side line cross. Figure 3 illustrates the layout procedure.

1-13. The fourth corner can be located by laying out the length of the side from the third corner along the opposite side line. After the corner has been determined and marked, you must stretch a cord between the first and fourth batter boards so that it passes directly over the nailheads in the first and fourth corner stakes.

1-14. *Squaring the building*. At this point, the lengths of the building sides have been established and the corners should be properly located. However, since there is a possibility that the corners are not square, you should check them by measuring the diagonals of the building. If the diagonals are not the same length, the building is not square. In this case, the third and fourth stakes must be moved along the opposite side line until the diagonals are even. When you check the diagonals, the exact length of the building must be maintained between the third and fourth stakes. The four corners that have been located are the exact corners of the building. Cords connecting these four corners will represent the building line.

1-15. The excavation line may sometimes be the same as the building line; but in most cases, it is located 2 or 3 feet outside the building line. By placing the excavation line 2 to 3 feet outside the building line, you allow room to erect the forms for the foundation walls. After the final layout has been checked, saw cuts should be made in the outside edges of the batter boards to hold the line in place. When the saw cuts (kerfs) have been made, the lines can be removed and replaced whenever they are needed for reference during excavation and foundation construction.

1-16. **Building Materials.** Once the site has been selected and the building lines have been established, you will have need for the many different materials which will be used in the building. The jobs are scheduled so that they will be done in an orderly sequence. The building materials must be ordered to arrive as needed, also. However, the arrival of materials is sometimes delayed for various reasons. When materials fail to arrive as needed, schedules are interrupted and must be revised. After the schedules are changed, the materials ordered according to the original plans may be received on the site before they can be used. The stacking and storing of the materials must be arranged so that they may be efficiently used when they are required.

1-17. *Ordering*. The scheduling of jobs and ordering of materials is usually done by work control specialists and technicians. You must, however, keep them advised of work progress and conditions at the site which may change the sequence of work tasks or the requirement for particular materials. Good thinking and planning for future needs is required because there is often a considerable period of time between the date that materials are ordered and the date they arrive on the site. It is a good practice to have materials delivered at least a short time before they are to be used. This allows for proper stacking and storing of the materials and often prevents delays and rescheduling.

1-18. *Stacking and storing*. You will always stack lumber according to the procedures which you learned in Volume 1, using dunnage to allow free air circulation through the pile. It is also important that the materials be placed in the proper locations. Particular types of lumber and supplies should be stacked as near the area where they will be used as possible. Where materials, such as wall framing lumber, are to be used throughout the structure, you may stack several piles around the structure. When one material must be stacked on top of another, be sure you place the one to be used earlier on top. Never stack materials in front of doorways so that they prevent access by delivery vehicles. Many materials, which are subject to damage by exposure to the weather, are stored in the structure being built as soon as the roof is installed. Extra care must be used in selecting storage locations inside the building to prevent interference with work progress and the necessity for moving stacks and piles of materials.

## 2. Foundations

2-1. The construction of any building must start with a foundation. Foundations may be constructed of cut stone, rock, brick, tile, wood, or concrete. The material used will depend upon the type of structure, the availability of the material, and the amount of weight it must support. An inadequate foundation will result in uneven settling, and may cause cracked plaster, ill-fitted doors, or sticking windows.

2-2. **Wall Type.** Wall-type foundations are solid and usually form a continuous support for the external walls of a building. You will use them where heavy building loads are to be supported or when the structure is of permanent-type construction. Also, when a portion of a structure (as a basement) is below ground level, a wall-type foundation is used. These foundations are usually built of masonry, either laid bricks (including tile or blocks), rock, cut stone, or formed concrete.

2-3. **Pier (Column Type).** Piers or columns are used on constructions of a temporary nature. The use of piers or columns saves time, labor, and material. They are spaced according to the amount of weight to be carried. This spacing is generally from 6 to 10 feet. When wooden piers which extend more than 3 feet above the ground are used, you should strengthen them with crossties and diagonal braces.

2-4. **Bearing Piles.** Piles are columns of timber, steel, or concrete driven vertically into the ground to support a load. They are driven until they bottom on firm stratum or the friction of the earth around them is sufficient to permit the pile to carry the load. Piles are spaced according to the load they are to support.

2-5. **Footings.** Just as the foundation supports the building, the footing forms a solid base for the foundation and gives it firm support. Footings are usually wider than the foundation and thereby spread the weight of the foundation and its load over a greater area of the supporting earth. Location of the footings is usually below the soft loamy surface soil and below any possible frost line in geographical areas where ground frost occurs.

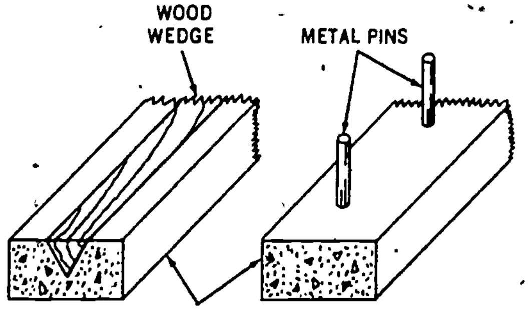



Figure 4. Methods of locking walls to footings.

2-6. These broad, flat bases for foundations are normally formed of concrete. They may be poured prior to or with the rest of the foundation. When the footing is poured separately, shifting of the foundation is prevented by keyways or metal pins, as illustrated in figure 4. Column footings should extend above ground or floor level to protect the column from deterioration due to dampness.

2-7. **Excavations.** It will be necessary, in many instances, to remove earth at the building site so that the foundation may be located correctly and firmly supported. The resulting excavations may be simple footing-shaped holes for columns, trenches for wall-type foundations, or extensive earth works for basements.

2-8. Before you start the excavation, it is advisable to recheck the location of the batter boards and the excavation lines. If excavations for footings are carefully squared and dug to the correct dimensions, forms for holding the concrete will not be required.

2-9. Trenches will usually be as wide as the required footing and are located so that the foundation wall will be centered in the excavation. If the wall forms require additional room for placing and bracing, the size of the excavation must be enlarged accordingly.

2-10. **Concrete Forms.** Concrete forms are made for molding concrete foundation footings, walls, and piers. This type of construction is the reverse of other constructions because the inside of the form is the finish side. Since the dimensions are all inside measurements, you must create a different mental picture from that required in ordinary construction. The blueprint will show the details of the foundation, but the features of the necessary forms must be determined by the personnel in charge of constructing them.

2-11. *Wall.* A concrete form is similar to a jacket placed around an object. The form is the reverse of the object to be formed, and every knot, rough grain in the material, or irregularity in the form will be duplicated in the finished concrete. The form is used to retain the plastic concrete until it sets and hardens. Most forms consist of three main members: retaining boards, supporters, and braces. These members are illustrated in figure 5.

2-12. For all walls above the ground and many underground walls, double-sided forms are required. These forms must be strong enough to prevent bulging from the pressure of the wet concrete. Tie wires are used to help prevent this bulging. There are several different types of wall forms that you may use. The type which you select will depend upon the dimensions of

140

the wall to be constructed, availability of form materials, time limits, and cost factors. The most common type of form used is the full unit form. This form is illustrated in figure 6.

2-13. The full unit form is used for casting long walls in sections. This type of form permits a long wall to be built in sections, using the same form for the different sections. After the first section is poured and set, the form is removed and repositioned for the next section. One end of the form is open to fit over the end which is overlapped when the form is shifted to the next section. Locking of the sections may be accomplished by extending the concrete reinforcing steel through the ends of the forms or by forming a tongue and groove, as shown in figure 6. The tongue board should be beveled slightly to allow easy removal of the end of the form.

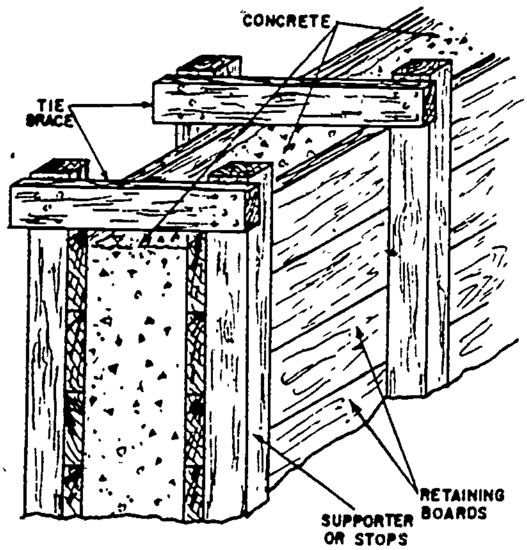



Figure 5. Main members of concrete forms.

2-14. A layer unit wall form builds a wall up in successive layers. This form is a modification of the full unit form with the sections built up vertically instead of horizontally. This type of form is used where high concrete walls are constructed which could not be poured in one continuous operation. These layers may be tied or locked in the same manner as the full unit formed wall, except that the groove or extended steel will be at the top of the wall form.

2-15. The continuous wall form is used when a long wall is to be constructed and cost is no problem. This type of form is not as economical as the full unit form because of the amount of lumber required. However, where time is more important, this type of form is always used.

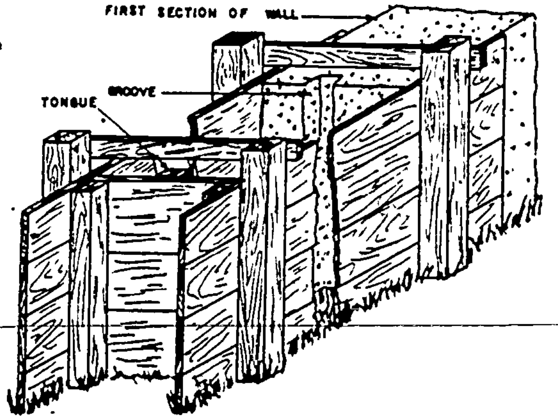



Figure 6. Full unit form.

2-16. *Pier and column.* Pier and column forms are boxlike forms open at the ends and suitably braced to prevent bulging or breaking. There are two general types of these forms: continuous and sectional.

2-17. A continuous form is suitable for short piers or columns and extends from the bottom to the top of the pier. A form of this type is slightly tapered so that it can be lifted from the formed concrete.

2-18. Sectional forms are used to build columns in sections. For easy dismantling and reassembling purposes, the forms are held together by bolts and wedges. The sectional form operates on the same principle as the layer unit form for walls. The concrete is poured and left to set and harden; then the form is dismantled and reset for the next section. For easy dismantling, double-headed nails are used. Figure 7 illustrates this form.

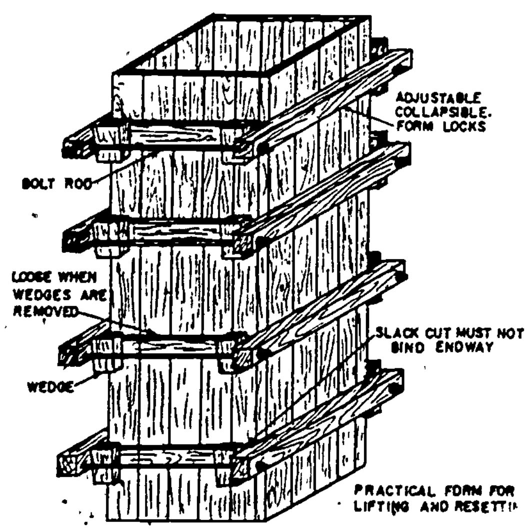



Figure 7. Sectional pier or column form.

2-19. *Footing.* If the excavation is greater than the width of the footing or the soil is such that the sides of the trench will not stand till concrete can be poured, wooden footing forms must be used. These will usually be simple, continuous wall forms anchored with stakes. Grade stakes are driven between the forms, as illustrated in figure 8, to assure proper thickness and easier leveling. You must remove the stakes before the concrete sets.

2-20. *Floor and sidewalk.* When a concrete floor or sidewalk is to be poured, a definite grade is required to obtain the correct thickness throughout the slab. To hold the concrete until it sets and hardens, a system of guides is used. This guide system involves an arrangement of screeds, as illustrated in figure 9.

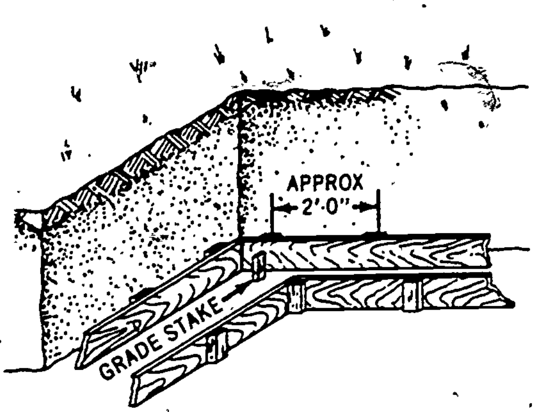



Figure 8. Wooden footing forms.

2-21. When this system of screeds is completed, the concrete is poured. A straightedge, resting on the screeds, is worked in a sawlike motion to bring the level of the concrete to the top of the screeds.

2-22. *Girder and beam.* Girder and beam forms are constructed from 2-inch-thick material dressed on all sides. The bottom piece of material should be constructed in one piece to avoid the necessity of cleats. The bottom piece of the form should never overlap the side pieces; the side pieces must always overlap the bottom. Figure 10 illustrates a beam girder form and shows how it should be nailed from the sides. The temporary cleats shown in the illustration are tacked on to prevent the form from collapsing when handled.

2-23. *Miscellaneous forms.* Many types of forms are used for special purposes. There are circular forms and other curved shapes, forms for concrete roofs, slip forms, forms for bridge abutments and wings, and many others. This

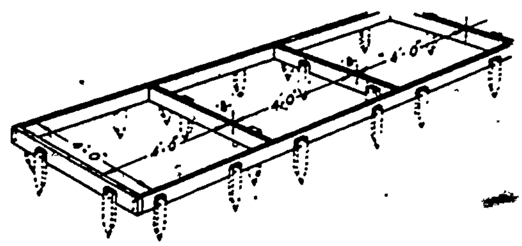


Figure 9. Screed arrangement.

section covers only the basic types you will use in general carpentry work.

2-24. *Materials.* The materials used in making forms are selected according to the strength required. However, because of almost universal use of wood in framing buildings and its availability at the building site, wood of certain common dimensions will normally be used.

2-25. Supporters and stakes will usually be 2 x 4's of the kind and grade of lumber specified for wall framing. If greater strength is needed, 2-inch dimension lumber of greater width may be used. One-by-four bracing is usually adequate.

2-26. Forms may be sheathed with retaining boards of many kinds of ordinary 1-inch finished lumber. Width of the lumber has little importance other than the time required in using narrower lumber. In this respect, use of ¾-inch plywood has distinct advantages. Because of its ability to withstand splitting and breaking, plywood is also useful in building curved forms. You will normally use 8d nails to install 1-inch finished lumber and ¾-inch plywood. When nailing 2-inch dimension lumber, use 16d nails. If the forms are to be reused and ease of dismantling is important, double-headed nails are useful.

2-27. *Bracing.* The weight of concrete (approximately 150 pounds per cubic foot) and its fluidlike, creeping characteristics place particular importance on the strength and rigidity of forms.

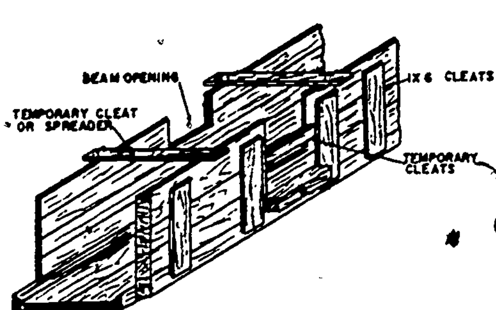



Figure 10. Girder and beam form.

Adequate bracing must be used to prevent movement of the forms from the proper settings. After the cement is poured into the forms, realinement is very difficult. There are many ways to brace forms but proper methods will do the job with the least amount of materials.

2-28. Bracing consists of boards nailed to the form supporters and to stakes driven firmly into the ground. Common methods of bracing are illustrated in figure 11. The size of material and number of braces used must be determined by considering the dimensions and weight of the wall and the stake-holding characteristics of the ground.

2-29. When forms require extra strength, they may be braced, or supported, with whalers. Whalers are beams made from 2-inch or greater dimension lumber of width sufficient to give the required strength. The whalers are installed with their edge to the back of the form supporters, and horizontally along the length of the form. In addition to toe-nailing them to the form supporters with 16d nails, you should install tie-wires around the whalers. The tie-wires are usually of soft, black No. 9 wire and should extend through the forms and around the whalers on the other side of the forms. Spacers, made of 1- x 2-inch material, are installed near the tie-wires to maintain a uniform distance between the forms when the tie-wires are twisted to firmly tighten them. You should nail the spacers, through the form sheathing, with a 6d nail on one end only. This allows them to be easily removed as the concrete is poured.

2-30. *Removal and maintenance.* After the concrete has hardened, the forms are removed. This removal process is called stripping. When removing (stripping) forms, exercise care and avoid damaging the concrete and/or forms. Sectional or unit forms should be oiled and stored for future use. Save the lumber from forms built up at the site by sorting it, clearing it of nails, and piling it for use in the structure to be built.

## 3. Floor Framing

3-1. Now that you have learned the methods for building a substantial foundation, let's move on to the task of constructing a framework to support the floor.

3-2. Actually, this framework will support the contents of the building and its superstructure as well as the floor. The importance of strength in this part of a building is possibly second only to that of the foundation. Of the several methods for constructing floor framing, we will discuss the ones most commonly used.

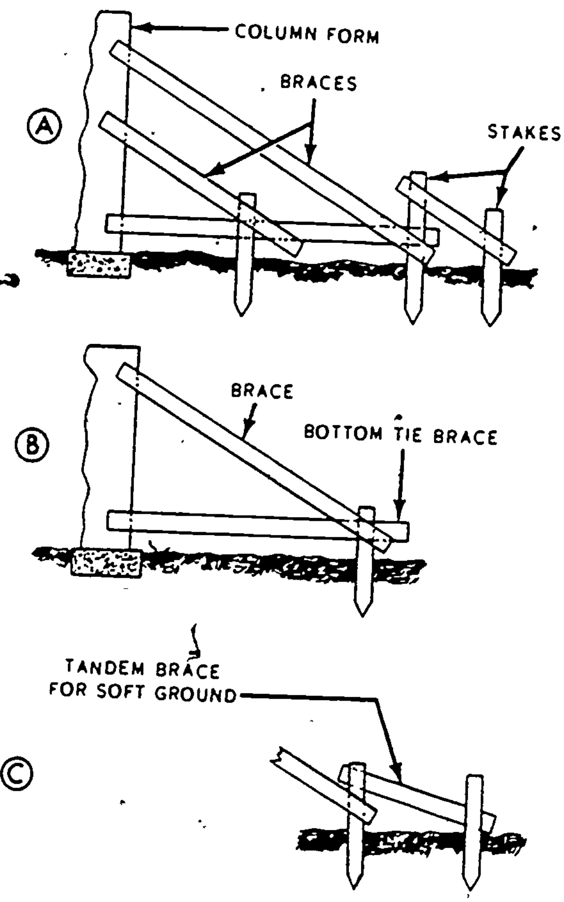



Figure 11. Methods of bracing.

3-3. The major parts of a floor frame are the sills, girders, and joists. Because it is the first member placed on the foundation, we will first consider the sill.

3-4. **Sills.** A foundation sill is a plank or a timber that rests on top of the foundation wall. It acts as a base and forms the support, or bearing surface, for the outside walls of a building. As a general rule, the first floor joists rest upon the sill. Sills, which are fastened to the foundation wall with anchor bolts, provide a nailing surface for the remainder of the framing. These anchor bolts are placed when the foundation is poured.

3-5. *Types of sills.* There are two general types of sill construction: solid and built-up. Figure 12 illustrates a solid sill. The sill plate upon which the joists and sidewall rest is a solid member bolted to the masonry. The joints at the corners are half-lapped together. The T-sill, which is classified as a built-up sill (fig. 13), is so called because the joist header is located near the center of the sill and the two members form an inverted T. This is the more modern type of

143

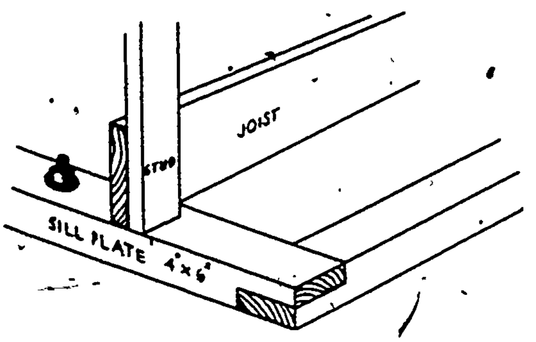



Figure 12. Solid sill construction.

sill, which may be used in modern braced frame construction. The sill plate should be so constructed that it will form a straight and true surface on which the joists and sidewalls rest. The corner joints, if butted together, may be lapped or strapped. The sidewall studs rest directly on the sill plate, thus reducing the bearing members of horizontal grain to a minimum.

3-6. The header at the end of the joists prevents drafts between the studs and joists. It also provides solid sill construction and a firm base upon which to nail the subfloor. This header may be cut in between the joists or may be spiked to the ends. The method you will use depends on the width of the sill plate. The joists should have a bearing seat on the sill plate of at least 4 inches. If the header is spiked against the ends of the joists, the sill plate would be 2" x 10". If they are cut between the joists, the sill would be 2" x 8".

3-7. A box, or L-sill, is another type of built-up sill (fig. 14) and is generally used in the platform type of framing. It provides the advantages of the single sill, the fire-stop, and the solid bearing upon which to nail the subfloor. The disadvantage of this type of sill is that the sidewall studs rest on horizontal grain of considerable thickness. This thickness is equal to that of

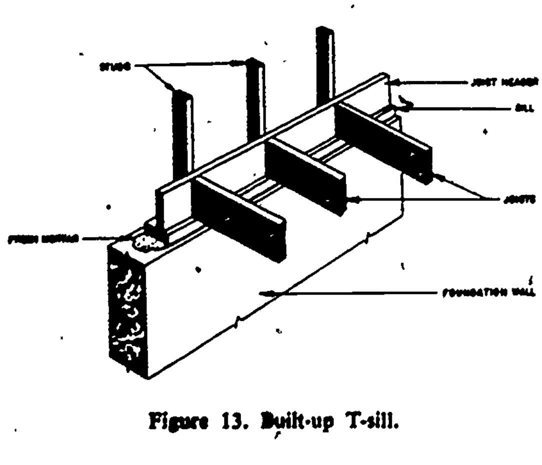


Figure 13. Built-up T-sill.

the soleplate, subfloor, joists, and sill. Notice that the subfloor runs to the outside header of the sill and must be laid before the inside wall partitions are raised.

3-8. *Size and materials.* Sizes of sills vary for the various types of construction. For small buildings of light-frame construction, a 2" x 6" sill is large enough under most conditions. For two-story structures and in localities that are subject to earthquakes or high winds, a sill 4 inches deep is desirable. This larger sill affords more nailing surface for diagonal sheathing brought down over the sill and ties the wall framing firmly to the foundation.

3-9. Material for sills may be of practically any locally available wood. No. 1 common lumber should be used for standard permanent con-

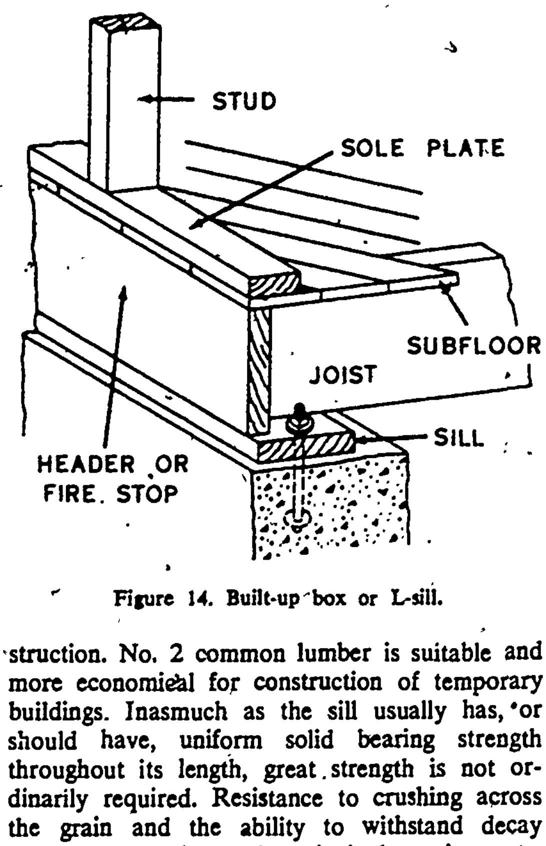



Figure 14. Built-up box or L-sill.

struction. No. 2 common lumber is suitable and more economical for construction of temporary buildings. Inasmuch as the sill usually has, or should have, uniform solid bearing strength throughout its length, great strength is not ordinarily required. Resistance to crushing across the grain and the ability to withstand decay and insect attack are the principal requirements.

3-10. *Preparing and anchoring.* The length of the sill is determined by the outside finish of the building. Measurements for the outside of a building are generally made from the outside face of the sheathing or subsiding. If the outside surface of the wall is to be stuccoed, the outside edge of the sill should be placed even with the outside edge of the foundation wall. When this is done, the sheathing can be carried down and over the foundation wall an inch or so below the bottom of the sill. When siding is used instead of stucco, the siding provides this overlap below the sill for weather protection.

3-11. For most ordinary construction, the sill is placed with its outside edge approximately ¾ inch in from the outside edge of the foundation. This space will make the outer face of the sheathing flush with the outside of the foundation wall.

3-12. When a sill of 2-inch material is used, it is good practice to have one piece extend the full length of the wall. If this full length piece is not practical, a butt joint along the exterior wall of the building is sufficient and entirely satisfactory when the sill is properly anchored. A butt joint is also recommended for corner joints with a 2-inch sill. All joints should be made as square and tight as possible.

3-13. Anchoring the sill is important, and in order that the sill can be placed flat upon the foundation, it is necessary to bore holes through it for the anchor bolts. Because the location of the sill on the foundation determines the size of and squareness of the building, these bolts must be laid out very accurately. The hole locations on the sill are usually marked by placing the sill on top of the foundation along the side of the anchor bolts. This placement will mark the bolt spacing along the sill, but the distance from the edge must be determined by measuring. The distance from the outside edge of the foundation wall to the center of each bolt must be measured. If the outer face of the sheathing is to be flush with the outside edge of the foundation, the thickness of the sheathing must be subtracted before marking the sill. Figure 15 illustrates laying out hole locations for sills.

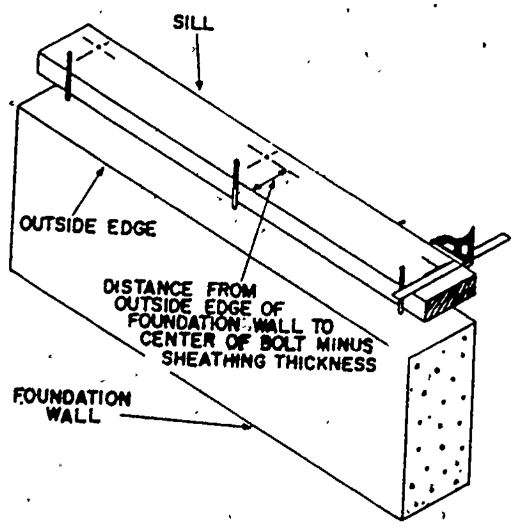



Figure 15. Laying out hole locations for sills.

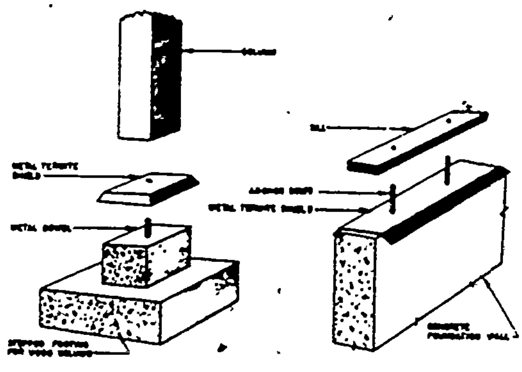


Figure 16. Termite shield.

3-14. The first consideration in placing the sill is that it must be level. This leveling will be difficult to do if the foundation itself is not level. It is good practice for you to spread a bed of mortar on the foundation and lay the sill upon it at once, tapping the sill gently to insure that the sill is level and rests firmly on the mortar throughout its entire length. After you set the sill in the mortar, place the nuts and flat or O.G. washers over the bolts and tighten them with your fingers. After the mortar has set a day or two, the nuts may be securely drawn down. This method of placing a sill in mortar provides a level foundation for the sill and prevents air leakage between the sill and the foundation wall.

3-15. *Protection from termites.* Frame buildings have several natural enemies which are constantly trying to destroy them. The most common of these are termites and wood-rotting fungi. Subterranean termites live underground, where there is moisture, so they must travel aboveground to feed on the wood. Because termites are sensitive to light, they sometimes build earthen tubes for traveling back and forth between the ground and wooden members of a building. If the termites' food supply is cut off, they will cease to thrive. The most effective way for you to cut off their food supply is by placing a metal shield between the foundation wall and the sill, as shown in figure 16. The shields should be made of galvanized iron or copper and should be placed over the top of all foundation walls, porch walls, piers, cellar posts, and any other place where wood rests on masonry. The shields should project on both sides of all walls and around all piers to prevent access from any side.

3-16. **Girders.** A girder is a large beam that supports other smaller beams or joists. It may be made up of several beams nailed together with 16d common nails; or it may be solid wood, steel, reinforced concrete, or a combination of these materials. A girder is generally used to support the ends of joists over a long span, thus taking the place of a supporting or bearing partition.

3-17. Girders carry a very large proportion of the weight of a building. They must be well designed, rigid, and properly supported at the foundation walls and on the columns. Precautions must be taken to avoid or counteract any future settling or shrinking that might cause distortion of the building. The girders must also be installed so that they will properly support joists.

3-18. Figure 17 shows the built-up girder. A shows the two outside masonry walls, B the built-up girder, C the joists, and D the support columns which support the girder B. This type of girder is commonly used in house construction. It is generally made of three planks spiked together with 16d common nails. Notice that the joists rest on top of the girder.

3-19. A girder with a ledger board upon which the joists rest is used where vertical space is limited. This arrangement is useful in providing more headroom in basements.

3-20. A girder over which joist hangers have been placed to carry the joists is also used where there is little headroom or where the joists carry an extremely heavy load and nailing cannot be relied on. These girders are illustrated in figure 18.

3-21. *Size requirements.* The principles which govern the size of a girder are:

*a.* The distance between girder posts.
*b.* The girder load area.
*c.* The total floor load per square foot on the girder.
*d.* The load per linear foot on the girder.
*e.* The total load on the girder.
*f.* The material to be used.

3-22. A girder should be large enough to support any ordinary load placed upon it; any size larger than that is wasted material. You should understand the effect of length, width, and depth on the strength of a wood girder before you attempt to determine its size.

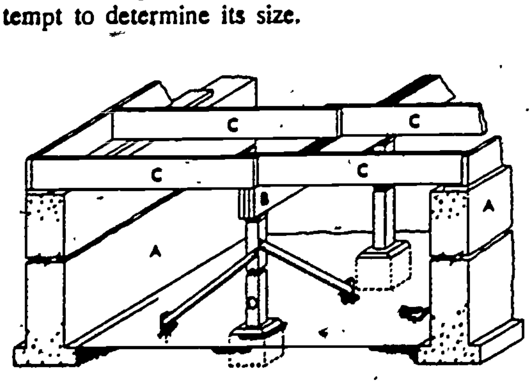



Figure 17. Built-up girder.

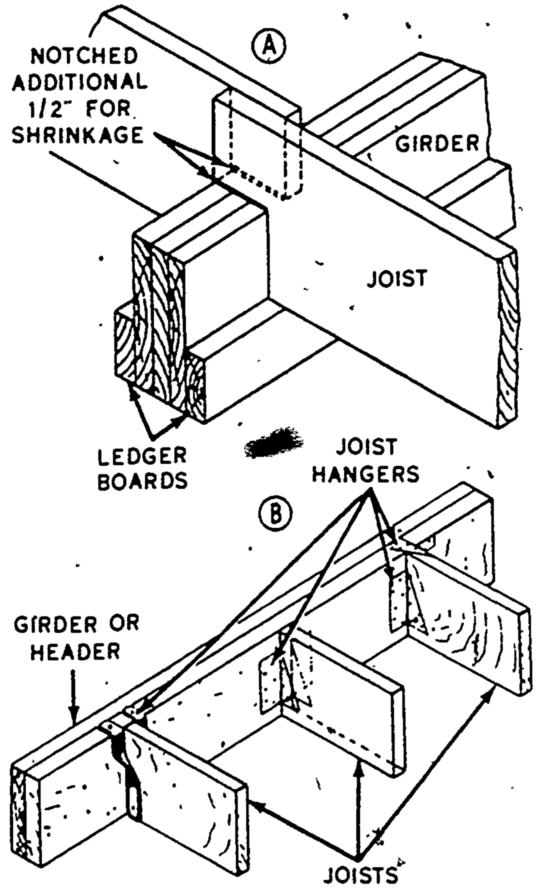



Figure 18. Joist to girder attachment.

3-23. When the depth of a girder is doubled, the safe load is increased four times. In other words, a girder that is 3 inches wide and 12 inches deep will carry four times as much weight as a girder 3 inches wide and 6 inches deep. In order to obtain greater carrying capacity through the efficient use of material, it is better to increase the depth within limits than it is to increase the width of the girder.

3-24. *Load area.* The load area of a building is carried by both the foundation walls and the girder. Because the ends of each joist rest on the girder, there is more weight on the girder than there is on either of the walls. Before considering the load on the girder, it may be well to consider a single joist. Suppose that a 10-foot plank weighing 5 pounds per foot is lifted by two men. If the men were at opposite ends of the plank, they would each be supporting 25 pounds.

3-25. Now assume that one of these men lifts the end of another 10-foot plank with the same weight as the first one, and a third man lifts the opposite end. The two men on the outside are each supporting one-half of the weight of one

146

plank, or 25 pounds apiece, but the man in the center is supporting one-half of each of the two planks, or a total of 50 pounds.

3-26. The two men on the outside represent the foundation walls, and the center man represents the girder; therefore, the girder carries one-half of the weight, while the other half is equally divided between the outside walls. However, the girder may not always be located halfway between the outer walls. To explain this, the same three men will lift two planks which weigh 5 pounds per foot. One of the planks is 8 feet long and the other is 12 feet long. Since the total length of these two planks is the same as before and the weight per foot is the same, the total weight in both cases is 100 pounds.

3-27. One of the outside men is supporting one-half of the 8-foot plank, or 20 pounds. The man on the opposite outside end is supporting one-half of the 12-foot plank, or 30 pounds. The man in the center is supporting one-half of each plank, or a total of 50 pounds. This is the same total weight he was lifting before. A general rule that can be applied when determining the girder load area is that a girder will carry the weight of the floor on each side to the midpoint of joists which rest upon it.

3-28. *Floor load.* After the girder load area is known, the total floor load per square foot must be determined in order to select a safe girder size. Both dead and live loads must be considered in finding the total floor load.

3-29. The first type of load consists of all weight of the building structure. This is called the dead load. The dead load per square foot of floor area, which is carried to the girder either directly or indirectly by way of bearing partitions, will vary according to the method of construction and building height. The structural parts included in the dead load are:

- Floor joists for all floor levels.
- Flooring materials, including attic if it is floored.
- Bearing partitions.
- Attic joists for top floor.
- Ceiling lath and plaster, including basement ceiling if it is plastered.

3-30. For a building of light-frame construction similar to an ordinary frame house, the dead load allowance per square foot of all the structural parts must be added together to determine the total dead load. The allowance for average subfloor, finish floor, and joists without basement plaster should be 10 pounds per square foot. If the basement ceiling is plastered, an additional 10 pounds should be allowed. When girders (or bearing partitions) support the first floor partition, a load allowance of 20 pounds per square foot is used. Another 10 pounds must be allowed for ceiling plaster and joists when the attic is unfloored. If the attic is floored and used for storage, an additional 10 pounds (per sq. ft.) should be allowed.

3-31. The second type of load to be considered is the weight of furniture, persons, and other movable loads which are not actually a part of the building but are still carried by the girder. This is called the live load. Snow on the roof is considered a part of the live load. The live load per square foot will vary according to the use of the building and local weather conditions. The allowance for the live load on floors used for living purposes is usually 30 pounds per square foot. If the attic is floored and used for light storage, an additional 20 pounds per square foot should be allowed. The allowance per square foot for live loads is usually governed by specifications and regulations.

3-32. When the total load per square foot of floor area is known, the load per linear foot on the girder is easily figured. Assume that the girder load area of the building shown in figure 19 is sliced into 1-foot lengths across the girder. Each slice represents the weight supported by 1 foot of the girder. If the slice is divided into 1-foot units, each unit will represent 1 square foot of the total floor area. The load per linear foot of girder is determined by multiplying the number of units by the total load per square foot. You will note in figure 19 that the girder is off center. Therefore, the joist length on one side of the girder is 7 feet (one-half of 14 feet) and the other side is 5 feet (one-half of 10 feet), for a total distance of 12 feet across the load area. Since each slice is 1 foot wide, it has a total floor area of 12 square feet. Now, if we assume that the total floor load for each square foot is 70 pounds, multiply the length times the width (7′ × 12′) to get the total square feet supported by the girder (7′ × 12′ = 84 sq. ft.).

84 sq. ft.
× <u>70</u> lb. per sq. ft. (live and dead load)
5,880 lb. total load on girder

3-33. *Material.* Girders may be made of either wood or steel, depending on the type of construction. Wooden girders are more common in small frame-type buildings. You may use solid timber, or you may build them up by using two or more 2-inch planks. Built-up girders have the advantage of not warping as easily as solid wooden girders and are less likely to have decayed wood in the center.

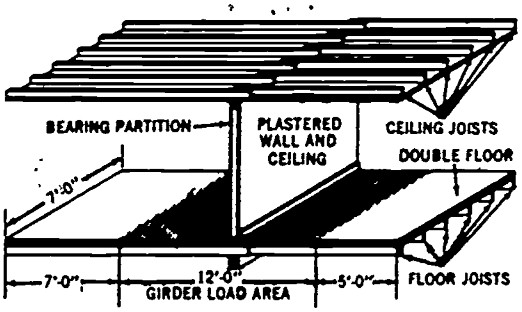



Figure 19. Girder load area.

3-34. When built-up girders are used, the pieces should be securely spiked together to prevent them from buckling individually. A two-piece girder of 2-inch planks should be spiked on both sides with 16d common nails. The nails should be located near the bottom, spaced approximately 2 feet apart near the ends and 1 foot apart in the center. A three-piece girder should be nailed in the same manner as a two-piece girder.

3-35. Regardless of whether the girder is built-up or solid, it should be of well-seasoned material. For a specific total girder load and span, the size of the girder will vary according to the kinds of wood used. The reason for this variation is that some kinds are stronger than others.

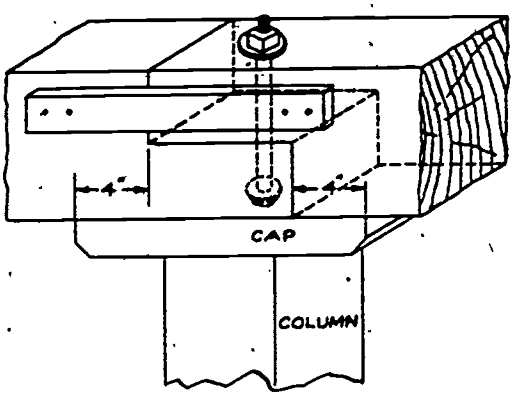
3-36. *Splicing*. To make a built-up girder, select straight lumber free from knots and other defects. The length of the stock should be great enough so that no more than one joint will occur over the span between footings. The joints in the beam should be staggered, with care taken to insure that the planks are squared at each joint and butted tightly together. Sometimes a half-lap joint is used to join solid beams. In order to do this correctly, the beam should be placed on one edge so that the annual rings run from top to bottom. The lines for the half-lap joint are then laid out as illustrated in figure 20, and the cuts are made along these lines. The cuts are then checked with a steel square to assure a matching joint. To make the matching joint on the other beam, proceed in the same manner and repeat the process. The next step is to tack a temporary strap across the joint to hold it tightly together. Now drill a hole through the joist with a bit about $1/16$ inch larger than the bolt to be used. Fasten together with a bolt, washer, and nut.

3-37. Another type of joint is called the strapped butt joint. The ends of the beam should be cut square, and the straps, which generally are 18 inches long, are bolted to each side of the beams.

3-38. *Supports*. When building small houses where you do not have the services of an architect, it is important that you have some knowledge of the principles that determine the proper size of girder supports.

3-39. A column or post is a vertical member designed to carry the live and dead loads imposed upon it. It may be made of wood, metal, or masonry. The wooden columns may be solid timbers or may be made up of several wooden members spiked together with 16d or 20d common nails. Metal columns are made of heavy pipe, large steel angles, or I-beams.

3-40. Regardless of the material used in a column, it must have some form of bearing plate at the top and bottom. These plates distribute the load evenly over the cross sectional area of the column. Basement posts that support girders should be set on masonry footings. Columns should be securely fastened to the load-bearing member at the top and to the footing on which they rest at the bottom. Figure 21 shows a solid wooden column with a metal bearing cap drilled to provide a means of fastening it to the column and to the girder. The bottom of this type of column may be fastened to the masonry footing by a metal dowel inserted in a hole drilled in the bottom of th column and in the masonry foot-



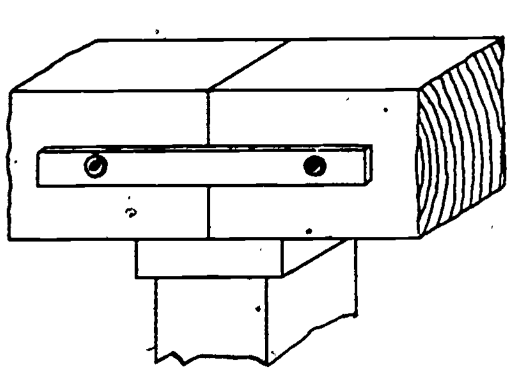



Figure 20. Half-lap and butt joints.



47

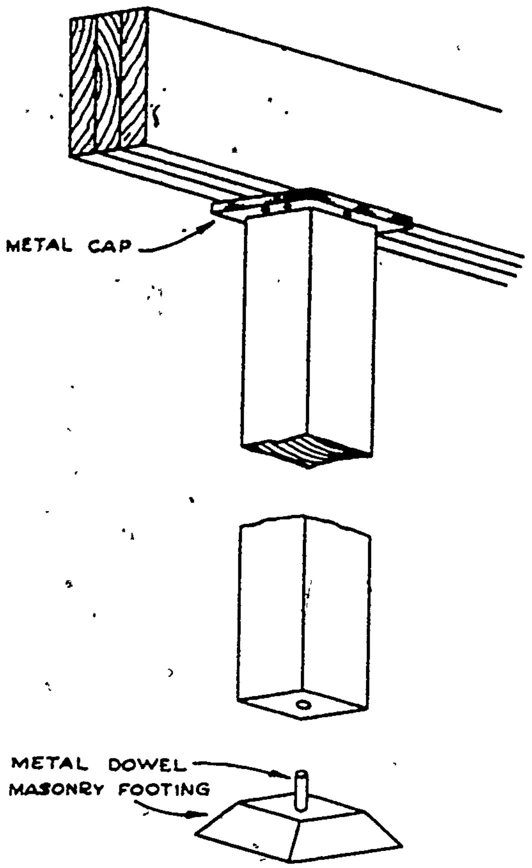



Figure 21. Solid wood column with metal bearing cap.

ing. The base at this point is coated with asphalt to prevent rust or rot.

3-41. When locating columns, it is well for you to avoid spans of more than 10 feet between columns that are to support the girders. The farther apart the columns are spaced, the heavier the girder must be to carry the joists over the span between the columns.

3-42. A good arrangement of the girder and supporting columns for a 24- x 40-foot building is shown in figure 22. Column B will support one-half of the girder load existing in the half of the building laying between the wall A and column C. Column C will support one-half of the girder load between columns B and D. Likewise, column D will share equally the girder loads with column C and the wall E.

3-43. **Joists.** Floor joists are the wooden members which make up the body of the floor frame. The joists also act as a tie to bind and stiffen the frame of the building. Floor joists support the loads of the rooms they span. For example, the load on the joists under the kitchen of a house would be the weight of the joists, subfloor, finish floor, lath, plaster, sink, cupboard, and all other immovable objects carried by the joists. In addition, it would include the stove, refrigerator, and other movable objects in addition to any persons in the room.

3-44. *Types, sizes, and materials.* Floor joists and ceiling joists are considered the same because the only difference between the two is the amount of load they carry. Naturally, the floor joists carry the floor load and the ceiling joists carry the load of the ceiling. In a two-story building, however, the floor joists for the second floor also serve as ceiling joists for the rooms below. Therefore, these joists carry the weight of both ceiling and floor.

3-45. The principles which govern the size of a joist are the same as for a girder, and the size can be determined in the same manner. An important item for you to consider when selecting the size of a joist is its load-carrying capability.

3-46. Joists, either floor or ceiling, should be long enough to give a sufficient bearing to each end. In frame buildings, a minimum of 3 inches is usually satisfactory for ceiling joists, but at least 4 inches is preferred for floor joists. This makes the total length of the joists either 6 or 8 inches longer than the distance between the inside faces of the framework on which they rest. The bearing for joists in masonry work should never be less than 4 inches. With stone, rubble, and similar material, a minimum of 6 inches is recommended because of possible irregularities of the supporting material.

3-47. Joists may be spaced 12, 16, or 24 inches from the center of one joist to the center of the next one. A distance of 24 inches, however, is too great for proper stiffness in most cases, and the 12-inch spacing, except where extreme loads are borne, is considered too expensive. Therefore, a spacing of 16 inches has become the accepted standard for joists except where framing requires special consideration. Because of a partition overhead or some other reason, it may often be necessary that you locate one or two joists at certain fixed positions which do not fall at any of the 16-inch points. It is desirable, nevertheless, to start at one end of a building and space joists at 16-inch intervals, regardless of special joists. This allows floor and ceiling materials with dimensions in multiples of 4 feet to be used without cutting.

3-48. *Placing and anchoring.* When joists are being selected and installed, the crowned or curved edge should be placed up. If the amount of crown is excessive, the piece should not be used for a joist but may be placed in some other part of the building where the straightness of the line formed by its edge is not so important.

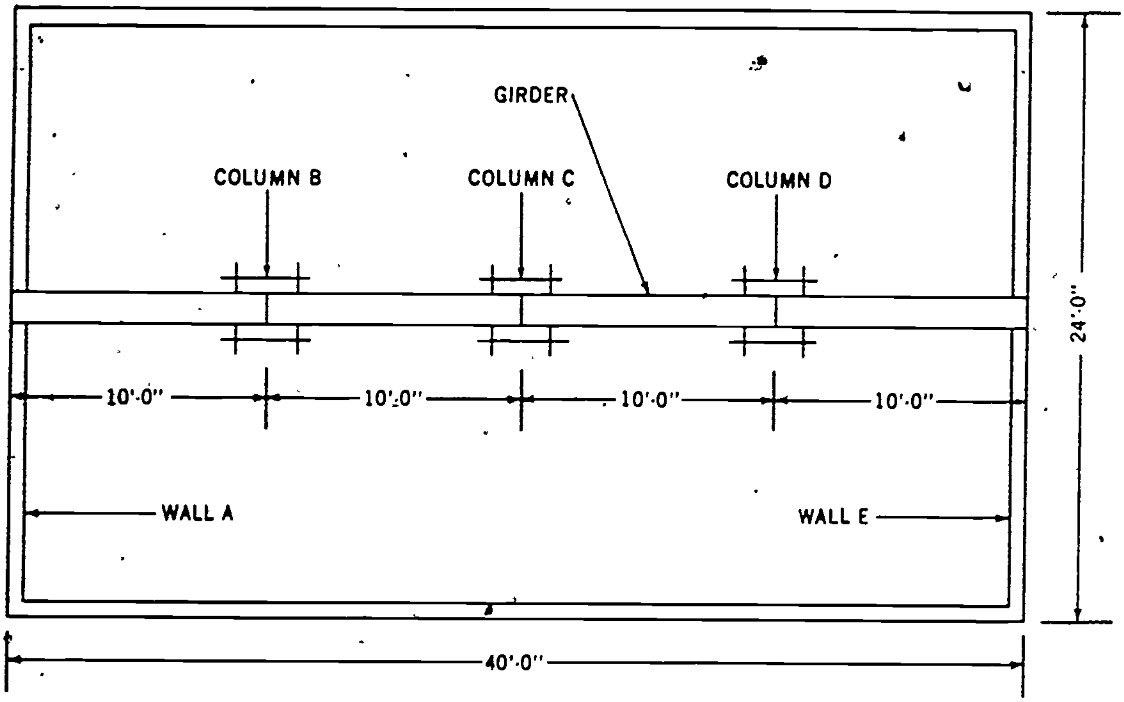



Figure 22. Column spacing.

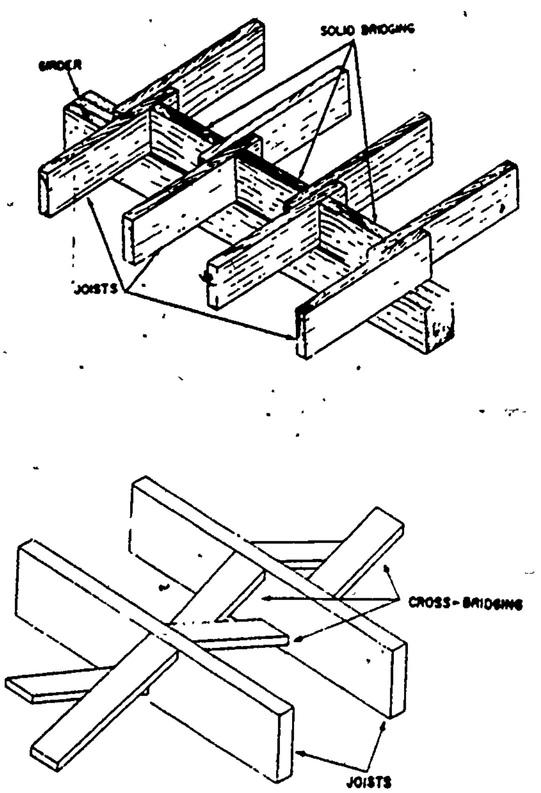



Figure 23. Solid and cross bridging.

3-49. The full width of a joist should be supported at the sill and at the girder. If joists are notched where they are framed at the girder or sill, a ledger board should be nailed on the side. The joist will then be supported, as shown in figure 18.

3-50. The method of nailing joists, as well as the size and quantity of nails, will differ with each type of framing. Of course, nailing of joists is impossible when brick is used. Metal hangers are used where heavy loads are expected and nailing cannot be relied on.

3-51. **Bridging.** Joists are braced by using bridging. There are two main types—solid bridging and cross bridging—as shown in figure 23.

3-52. Solid bridging is placed between the joists near the ends over supporting walls, partitions, or girders and serves to tie the joists together, preventing them from tipping or leaning. This bridging is usually made of joist material to fit between regular joists. For easier installation and better nailing, the solid bridging should be installed at the same time the joists are nailed in place. This type of bridging also serves as a fire stop. By obstructing circulation of air through the walls and in the area between the ceilings and floors of structures of more than one story, such bridging can delay the movement of hot gases and flames.

3-53. Cross bridging is placed in the middle portion of the joist span and acts as a brace or strut to distribute a concentrated load to several joists. This type of bridging is usually made of 1" x 4" material cut to fit diagonally between two joists. They are arranged in rows running at right angles to the joists. When determining the dimensions for cross bridging, measure the distance from the top of one joist to the bottom of the next joist. The required angle can be taken or copied with a T-bevel or combination square. You will lay out the length and angle on the edge of the material to be used for bridging. The bridging may be cut with an ordinary handsaw but more accurately with a mitre saw set. If available, a powersaw (either hand or table) set to the proper angle will save time.

3-54. **Floor and Ceiling Openings.** The regularity of joist spacing is often interrupted by openings required for stairways, chimneys, air ducts, and plumbing. You must place additional joists at these openings to assure that the proper strength of the floor or ceiling frame is maintained. These auxiliary joists are headers and trimmers.

3-55. *Headers.* The headers are placed at right angles to the regular joists, as shown in figure 24. They support the ends of the tail joists (tail beams), which result from cutting the regular joists to form an opening.

3-56. A header, in most cases, will not be made of material of greater width than the regular joists. The width required will vary, however, with the length of the header or with the length of the tail joists supported. An increase in either of these lengths will increase the load proportionately. It is a common practice to double all joist headers, regardless of their length. However, you should determine the size by considering the loads which must be carried. Many times, doubling the header may be unnecessary. On the other hand, there are situations where a doubled header will not be strong enough.

3-57. The length of a header is determined by the distance between the joists (trimmers) to which they are attached for support. Fastening of headers to joists may be done with ledger boards or metal hangers, similar to the way in

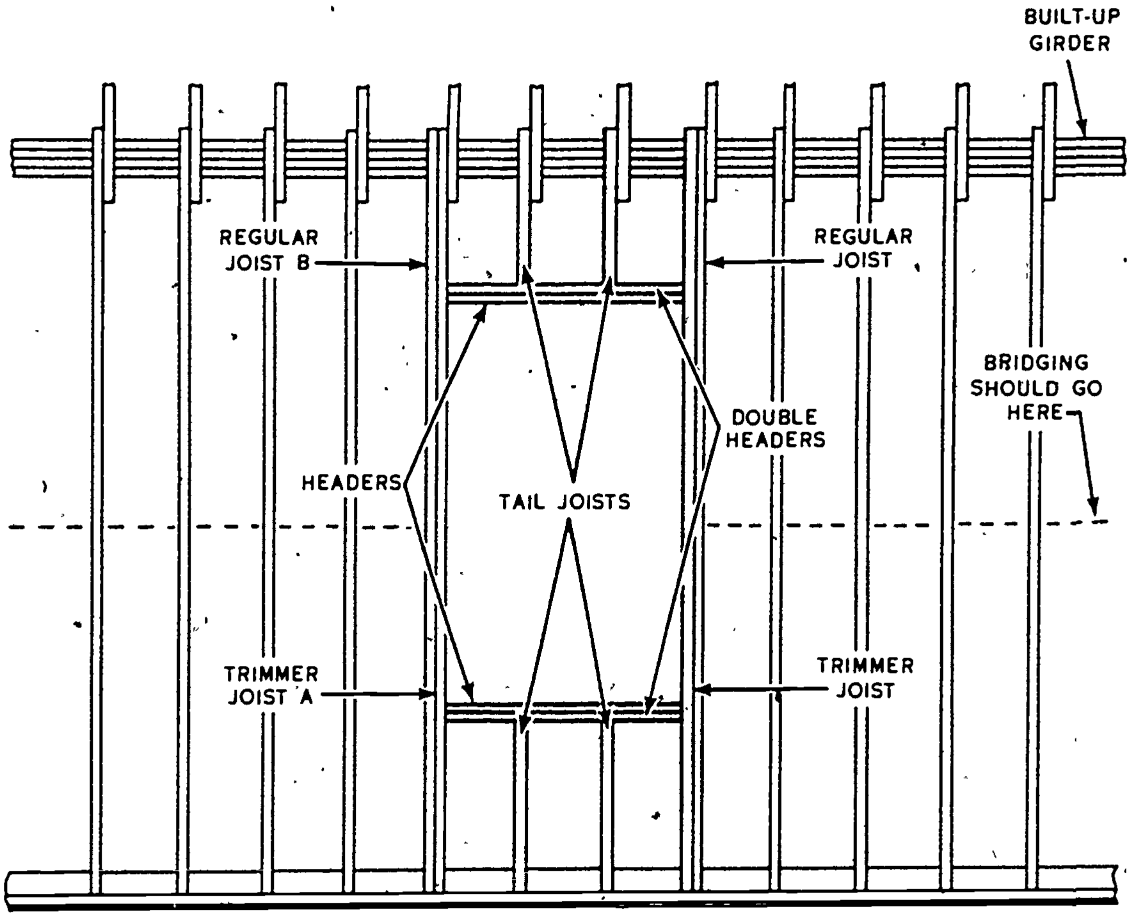



Figure 24. Joist and header trimmers.

which a regular joist is fastened to a girder, if effective nailing cannot be accomplished. Nailing is usually done by driving 16d nails through the joists into the ends of the headers.

3-58. *Trimmer joists (trimmers).* The floor framing members which form the sides of an opening that are parallel to the joists are called trimmers. The trimmers support the ends of the headers and carry the weight (load) of the headers and tail joists. Single trimmers are nailed to the sills like joists. Trimmers doubling with a regular joist are spiked to the regular joist and the sill.

3-59. When the side of an opening is formed by a regular joist, as A on figure 24, the joist is known as a trimmer. The auxiliary joist B becomes the regular joist in this case.

3-60. If air ducts or pipes are to be installed in partition walls, you will locate the joist to the side rather than directly beneath the wall. Usually joists will be required on both sides of the wall to support the additional weight.

3-61. *Chimneys.* The trimmers and headers for chimneys should be located 2 inches from each surface of the chimney to prevent the heat of the chimney from causing a fire. The space between the wood and the chimney should be filled with some noncombustible insulating material.

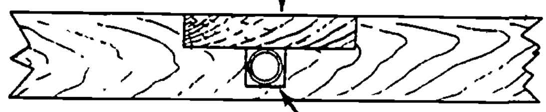



Figure 25. Reinforcing notched joist.

3-62. *Holes for pipes.* If a large pipe, such as a 5-inch drainpipe, must pass through several joists, it is advisable to frame in headers and trimmers. Where smaller pipes must run through joists, they should always be cut-in from the top edge. If a hole or notch of any considerable size is cut in a joist, the joist should be doubled or a block should be set in as illustrated in figure 25. Smaller holes drilled near the center of a joist will not decrease the strength to any great extent, because the upper and lower fibers have not been cut.

# Exterior Framing

ALTHOUGH SOMEONE has said, "Appearance is only skin deep," we must all agree that many of our likes and dislikes are based upon the looks of the person or object being considered. You have probably on many occasions selected an item from several which operated in the same way and performed to the same specifications, simply because you preferred the exterior appearance of the item. We often display our preferences in appearance through the style, model, or type of clothes we wear; car we drive; or house we live in. Because it is on the outside, the exterior framing and finishing of a building forms its looks. The methods and materials used in construction of exterior framing will reflect the likes and skill of the designers and builders. There are several methods of framing and finishing which may be used, and many kinds of materials are available. In most cases, the cost of construction and strength requirements for use of the building will be important factors in determining the materials and methods which you will use. Regardless of the kind of materials to be used or who has designed the building and determined the construction methods, you should try to do each task in a craftsmanlike manner. With each board which you cut and each nail that you drive, you will be leaving your mark on the external appearance of the building. To become a skilled craftsman, you must understand the materials, methods, and procedures to be used.

2. Let's make a quick mental examination of the exterior of an ordinary house (maybe your own home) to see what parts make up its external frame. Some of the parts will not be visible, for their purpose is to hold or support other parts. These hidden parts are framing members. It is the framing members which form the general shape of the house and give it strength. Our first glance will probably reveal to us the walls and roof of the house. We will discuss the details of wall construction in this chapter, whereas roof framing and materials will be explained in Chapter 3.

3. Our second, or closer, look at the house in our mind will possibly detect a particular covering, or exterior finish, on the walls of the house. The exterior finish of a building is intended to serve three purposes: (1) to protect the framework of the building, (2) to seal all cracks and crevices to prevent infiltration and escape of air, and (3) to decorate the framework and make it as pleasing as possible in appearance. All of these are important, and none should be neglected when you are constructing a building.

4. Undoubtedly you have also noticed certain openings in the walls. Doors for access and windows for ventilation and light are common in most buildings. Because they must be opened and closed, the weight and strength of doors and windows are less than those of the wall in which they are set. Constant wear and tear through use will make doors and windows the subject of frequent maintenance.

5. You may have observed a porch protruding from the door on your house. This porch serves as an external entranceway to the house. Porches may consist of a simple set of steps, a platform, a floor and roof, or a partially inclosed combination of floor and roof.

6. Because of the importance of external framing in the appearance of the building, for protection from deterioration, and for comfort, you should study this chapter with unusual care. If the instructions given are learned well, external framing work will be greatly simplified for you.

## 4. Wall Framing

4-1. We discussed the importance of a good solid foundation in Chapter 1, but a building must also have a well-built superstructure—all that part above the basement or foundation. In this section we will discuss the members and common methods used for constructing external wall frames.

4-2. The foundation walls of a building form the bearing walls for the upper structure and an

153

inclosure for the basement. Outside walls rest directly on the foundation walls with sills acting as anchors for them and forming the bearing walls for the roof. The upper story walls and inclosures for the entire inner construction are also carried by the bearing walls.

4-3. Like the floor frame, the wall frame is made of several kinds of members. Although the wall stands vertically from the floor to the roof, the members of the frame may also lie horizontally or on an angle. Each of these members serves a particular purpose and must be cut and placed properly for the wall to be structurally sound. Just as there are several ways to do many tasks, wall frames may also be assembled by several methods. We will discuss the methods which are most commonly used. First, let's become thoroughly acquainted with the individual members of the wall frame; then we will explain the framing methods which you may use.

4-4. **Framing Members.** As in any framework, there must be members which form the bottom, top, and sides. However, the members which are most numerous are those which fill in and connect the sides, and the bottom to the top. In the wall frame, probably the most important member and certainly the one that you will use most frequently is the stud.

4-5. *Wall studs.* Studs are the closely spaced vertical members of partitions and outside walls. Their purpose is to support the weight of the upper floors and provide a framework for exterior and interior finishes.

4-6. So general is the use of 2- x 4-inch material for studs in partitions and wall framing that little thought is ordinarily given to its strength requirements. Each individual stud in a weight bearing partition or wall acts as a column or post. It is well to remember that if the height of a column is more than fifty times its least unbraced dimension, it is unsafe. To keep within this ratio, an ordinary 2 x 4 standing unbraced should not be more than about 6 feet in height, which is approximately fifty times the smaller dimension of 1⅝ inches. The stud is braced along its weakest dimension by sheathing and siding on the outside and sheetrock or lumber on the inside. Therefore, for the studs of a partition or wall, the 3⅝-inch dimension is the controlling one in determining the bearing strength. For this reason, it is possible to use 2 x 4's as long as 15 feet with reasonable safety. For buildings over three or four stories in height, the lower stories may need additional strength. After the length of the studs has been determined, using a 6- or 8-foot ruler, measure the length of a stud and cut it with a handsaw. Using this stud, a pattern may be prepared, as shown in figure 26, for marking the other studs uniformly. The marked studs may then be cut rapidly with a portable power handsaw.

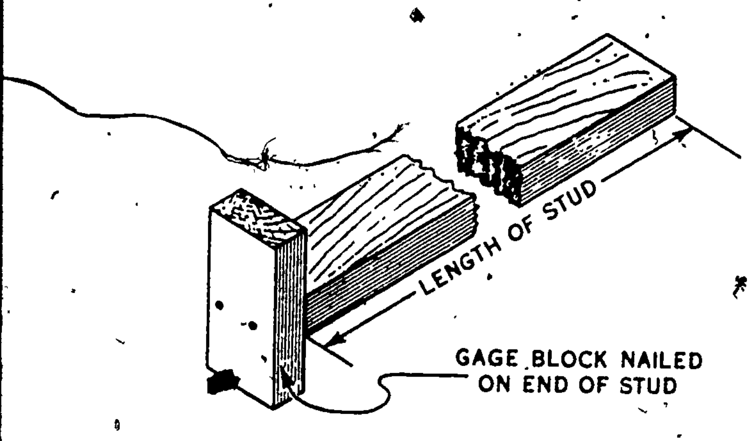



Figure 26. Pattern for marking stud lengths.

4-7. The spacing of studs is the same as spacing of floor or ceiling joists. Usually this spacing is 16 or 24 inches. The spacing is important, because it allows lapping of common sizes of wall covering materials on the studs. The stud spacing is laid out on the plates. You may place and nail studs in several ways. A common method in modern construction, where the bottom plate rests on the subfloor, is to assemble the studs and plates on the subfloor. Mark the stud spacing on the bottom (sole) plate, and place it on edge near the edge of the floor where it will be located. The studs may then be laid on edge with the bottom end against the marked soleplate. The top plate, marked with stud spacing like the bottom plate, is placed at the other end of the studs. In this position, you can easily nail the plates to the studs with two 16d nails at the end of each stud. After the frame is assembled, it can be raised into a vertical position as a unit. Where the soleplate is already in place, the bottom of studs must be toe-nailed in place. Twice as many nails are required when toe-nailing to assure equal strength. The tops of the studs, in this instance, are attached by nailing down through the top plate. When studs rest on a T- or L-sill, they are attached with two or three 16d nails driven through the header into the bottom edge of the stud.

4-8. *Plates.* A top plate is a horizontal member of a partition or frame wall. It serves as a cap for the studs and a support for the joists, rafters, and studs. Figure 27 shows double top plates that are lapped for greater strength. Top plates tie the studding together at the top and insure stud alinement, provide support for structural members above the plates, and also provide a base for the roof rafters which tie the roof and walls together.

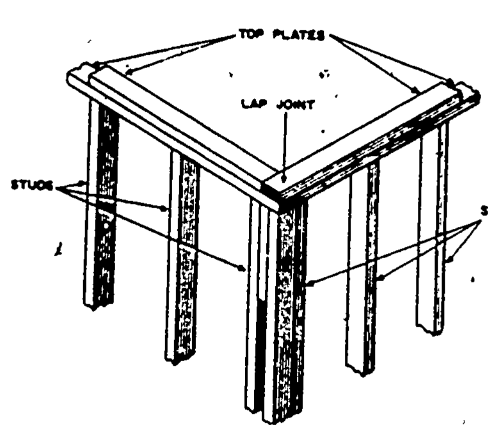



Figure 27. Double top plate.

To do all they are supposed to, top plates should be doubled at the top of walls and partitions and should have their joints staggered.

4-9. Where the wall studs do not rest on a sill, girder, or beam, a soleplate should be used (with dimensions not less than the studs). The layout of studs on the soleplate is illustrated on the right side of figure 28, whereas the left side shows the studs installed on the soleplate. Notice the regularity of the spacing interval except where partitions or walls are intersected. Corner posts, or studs, must be installed at these points.

4-10. *Corner posts.* There are several designs for corner posts. They may be either solid or built-up. In present-day construction, most corner posts are of the built-in type, as illustrated in figure 29. There are other types, but the one you will use will depend upon the requirements for a nailing surface for the exterior and interior wall coverings. Built-up corners have an advantage of allowing air circulation, whereas the solid type is more liable to deteriorate from decay. Regardless of the way corners are built-up, the material should be the best available, carefully selected and firmly nailed. You should remember that doubled 2 x 4's are not the same thickness as a 4 x 4. Two 2 x 4's (1⅝" + 1⅝" = 3¼"), assembled with a strip of ⅜" plywood between the boards, will have the same 3⅝" dimension as a 4 x 4. No matter how massive the corner post, it will require bracing to stand rigid against horizontal forces. Actually, the corner post is just a larger stud, located at the intersection of two walls. It is placed and nailed like a stud. Before permanently bracing the corner post, you must be sure that it is standing vertically and square. Vertical alinement may be made using several different tools and methods. A framing square, with the tongue lying on the soleplate and the blade against the side of the corner post, will aline the corner to 90° with the horizontal plate. Remember, you must check in both directions from the corner. By centering the end bubble of a common level held against the side of a corner post, you will bring it to a vertical position. Where the wind is not blowing, a plumb bob may be used. Hang the plumb bob from the top plate so that the point is just above the soleplate. When the corner is vertically alined, the point where the string is attached and the plumb bob point will be an equal distance from the corner post. A more accurate method is to use the "three, four, five" rule you learned in squaring building corners in Chapter 1. Using this method, you should measure and mark two points—on the corner post, 3 feet from the bottom, and on the soleplate, 4 feet from the corner post. When the corner post is vertical, the distance between these points should be 5 feet. For more accuracy, these distances can be doubled ("six, eight, ten").

4-11. *Bracing.* Diagonal wall braces are permanent parts of a building which serve to stiffen the walls, keep the corners square and plumb,

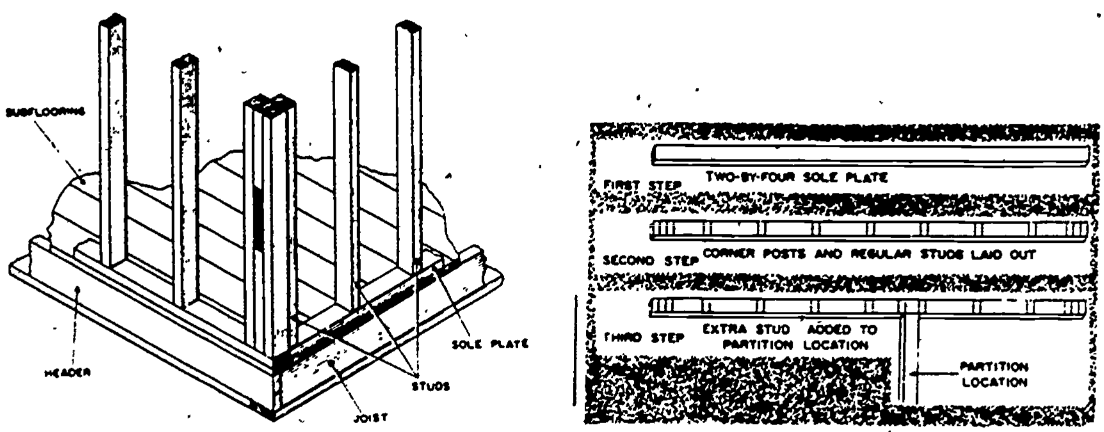



Figure 28. Layout of studs on soleplate.

155

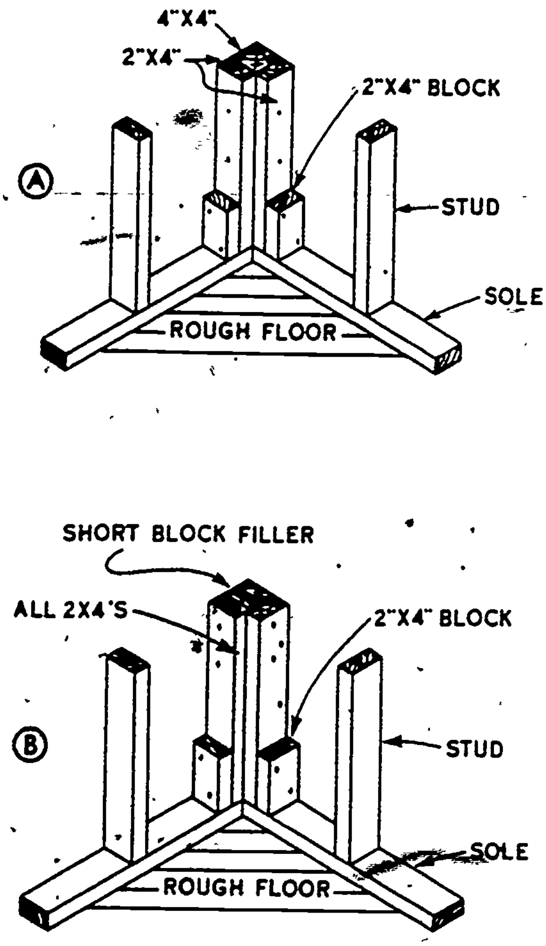



Figure 29. Types of corner post construction.

and prevent the frame from being distorted. Bracing is used at each corner of a building and should extend from the soleplate to the top of the corner post. The angle formed by the bracing and the plate should be from 40° to 60°. The common types of bracing which you will use are let-in, set-in, and block bracing.

4-12. Let-in bracing is usually done with 1- x 4-inch material. In the process of construction, the 1 x 4 is seated into cutouts in the sides of the studs and the corner post. The brace extends in a continuous piece from the soleplate to the top of the corner post, as shown in figure 30.

4-13. Short lengths of 2 x 4's nailed between the studs, as shown in figure 31, at an angle from the top of the corner to the soleplate form a set-in brace. This type of bracing does not have the strength of let-in bracing and also has the disadvantage of hindering the installation of wiring and plumbing. The use of set-in bracing is economical because short pieces of stud material, which might otherwise be considered waste, can be used.

4-14. Block bracing (block bridging) is similar to set-in bracing except that the 2 x 4's are installed horizontally, usually at a height of 48 inches from the floor. This type of bracing helps to keep the studs straight, provides a nailing surface for the edge of horizontal wall panels, and acts as a fire stop. This type of bridging is used extensively in modern construction. It does tend to block the wall, like set-in bracing, and you will have to cut into it to install or replace pipe or wires.

4-15. *Headers and trusses.* Where windows, doors, or other openings occur in outside walls, a portion of the regular studs must be cut out. Headers are installed to support the lower ends of these cut studs. In a like manner, there is a similar member which is called the rough sill at the bottom of openings, such as windows, which do not extend to the floor.

4-16. There are two classes of headers: nonbearing and load-bearing. Nonbearing headers are those positioned in walls that are parallel with the ceiling joists and which carry the weight of the framing immediately above. Load-bearing headers are those positioned in walls which carry the ends of floor joists and support the weight of the floor above.

4-17. Unless the opening in a nonbearing partition is more than 3 feet wide, a single 2 x 4 header, as shown in A of figure 32, is satisfactory.

4-18. On load-bearing partitions or walls, the header should be doubled, especially if a short stud is placed near the center of the header. If the 2 x 4's are placed side by side, the nailing is not as important, since each piece offers resistance to bending. It must be noted, however, that when the two 2 x 4's are laid on edge (side by side), the two together will measure 3¼ inches

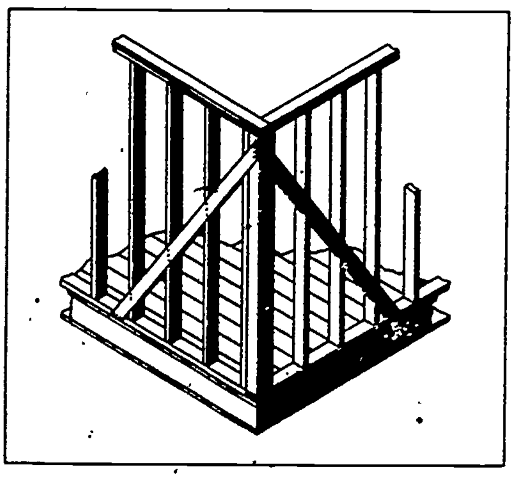


Figure 30. Let-in bracing.

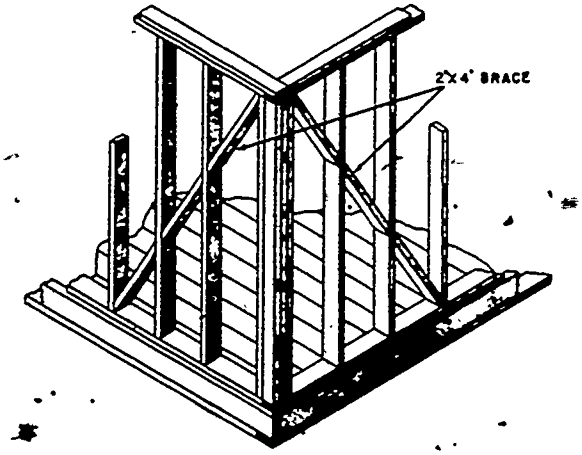



Figure 31. Set-in bracing.

instead of 3⅝ inches, and it will be necessary for you to insert small strips of ⅜-inch plywood between the 2 x 4's to make the header flush with the studs. A double header installation is illustrated in B of figure 32.

4-19. Where the opening is wide or where extra strength is required, a truss type of header may be installed. A truss over an opening in frame construction is a triangular arrangement of 2 x 4's forming a rigid framework to support the weight above. The stresses placed on such a truss are compression and tension. A variety of truss arrangements may be used. Figure 32,C, illustrates a simple truss.

4-20. There are other members which you will use for special purposes in framing external walls. However, those members which we have discussed are the major ones. Use of special purpose framing members will be presented when their application is discussed with framing methods.

4-21. **Framing Methods.** Now that we have completed our discussions of the individual members which you will use in building frame walls, let's go further and discuss the methods by which the members are assembled into the superstructure of wood frame buildings. You have noted in your trade that all buildings are not constructed in a like manner. They are similar in appearance, but when you cut a hole in the wall for a pipe, duct, etc. you find framing members where you thought none existed. You need to determine the framing methods used on your base for one- and two-story buildings. After you study the following text, you will be able to compare the figures with the drawings for buildings on your base and determine in advance where framing members are located.

4-22. The four distinctive types of framing

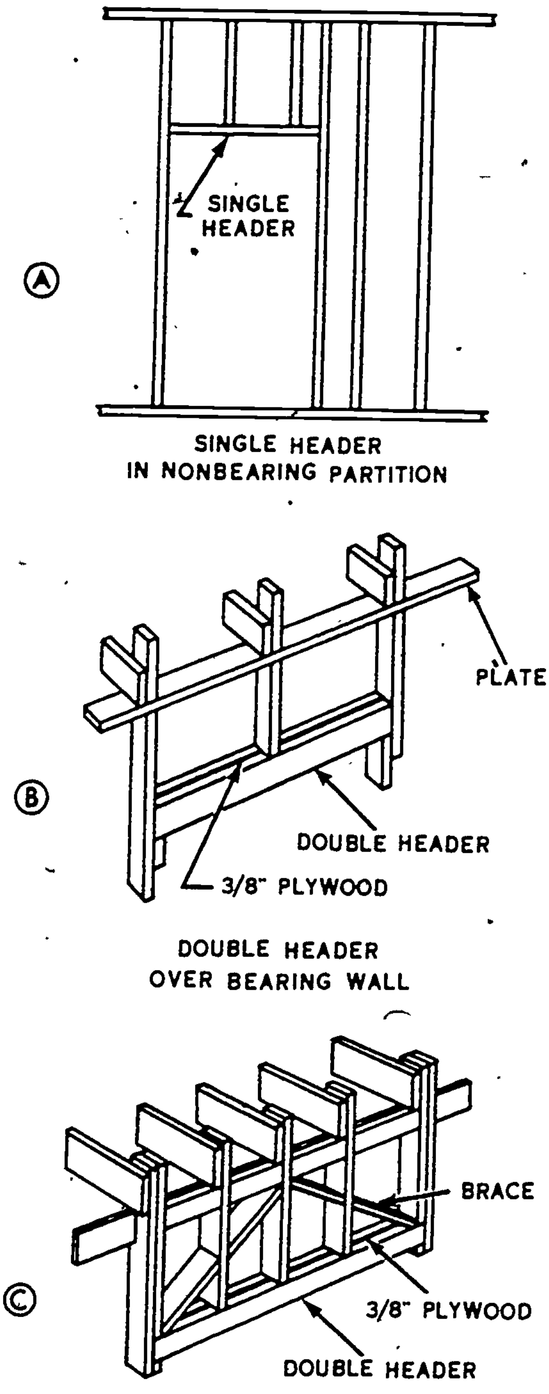



Figure 32. Types of headers.

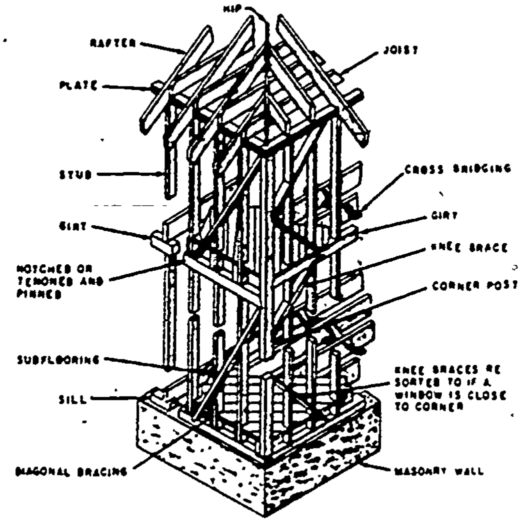



Figure 33. Braced framing.

that you should know are: braced framing, balloon framing, platform framing, and theater of operations framing.

4-23. *Braced framing.* Braced framing is the oldest type of framing in this country. Though it is a considerably modified form today, it is still used in the New England States. Some foreign bases have buildings that follow the heavy frame principle that distinguishes this frame from all others. The braced frame, shown in figure 33, has the heavy timber corner posts which extend from the sill plate to an equally heavy top plate at the roof line. Heavy timber girts extend between the corner posts to support the second floor. Braces are placed from each floor level to the corner posts and plate above. In areas where windows or doors are located near the corner, knee braces are substituted in place of the longer braces. This frame has been modified with lighter materials, and much of the handwork in making joints has been eliminated. The girts used now are too light to act as beams, and the wall studs have become an integral part of the structure, supporting the floor and roof in about the same manner as they do in other structures.

4-24. *Balloon framing.* The principal characteristic of the balloon frame shown in figure 34 is the use of studs extending from the sill plate to the top plate. Also, the joist ends are supported by ledger (or ribband) boards and are nailed to the studs. The ribband board is let into (seated in) the stud to form a rigid support for the joist. The balloon frame offers the advantages of speed and economy of construction as compared to the braced frame. The continuous studs facilitate easy installation of service pipe, conduit, etc., without cutting through plates and weakening the structure. Corner braces for this frame are lighter than in the braced frame and are let into the outside edges of the studs.

4-25. The braced frame and balloon frame are still in use on many of our posts; however, the platform frame is being used for most modern buildings now under construction.

4-26. *Platform framing.* Platform framing, also known as western-type framing, is the frame used in modern construction. It is distinguished by floor platforms independently framed, as shown in figure 35, the second and third floors being supported by studs one story in height. Framing of this type is fast, safe, and allows for extensive use of short materials. Interior partitions and exterior walls are framed with material of the same length, thereby insuring proper balance in case any shrinkage occurs. Because each floor is framed separately, the subfloor is laid "story by story" before the wall and partition studs are raised. The studs are fastened to a soleplate that in turn is fastened through the subfloor to the floor joists. It is very difficult to install service pipe or wiring in these walls after they have been covered.

4-27. *Theater of operations framing.* The theater of operations (TO) framing, shown in figure 36, has simple construction features that make it easy to assemble in a minimum amount of time. Most of this frame can be made of scrap materials salvaged from crates or other sources. Note the use of a spliced single top plate on the right-hand side of the figure; also, that the plates do not lap at the corners. This is not the recommended practice for good construction, but you will find many frames such as this being used in storage yards in overseas areas. A variation of

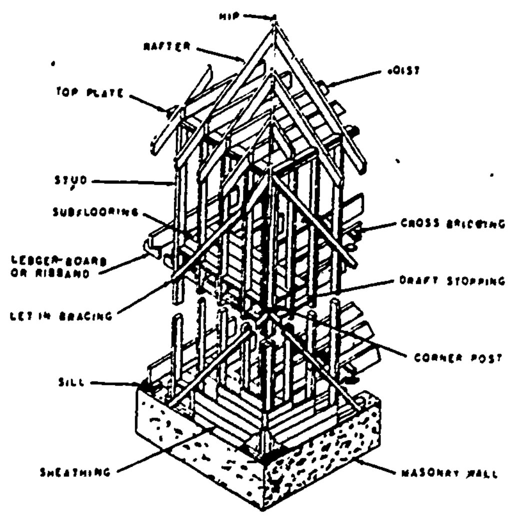



Figure 34. Balloon framing.

57

158

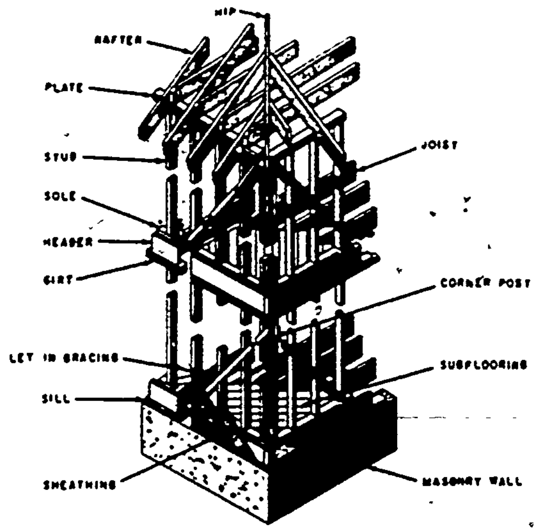



Figure 35. Platform framing.

this frame makes use of a concrete slab floor and regular 2 x 4 studs and plates. This frame has rafters spaced to rest on top of the studs. The entire frame is usually designed to support a standard military tent.

4-28. At this point in construction, you should have a good understanding about building the "skeleton" for the floor and outside walls. Next, we will study together the base covering of this frame. In the case of the floor, the base covering is called subflooring, whereas sheathing is the first covering for the exterior walls.

## 5. Subflooring and Wall Sheathing

5-1. The importance of and need for firm support has been emphasized in the building of foundations, floor frames, and wall frames. In the same manner, the finish materials for walls and floors depend upon the sheathing and subflooring as a supporting base for firm and secure attachment.

5-2. **Subflooring.** A subfloor is a wood floor usually of dressed 1-inch lumber laid over the floor joists and over which the finished floor is laid. A subfloor may be referred to as underfloor, rough floor, or base floor. The purposes served by a subfloor are sixfold:

(1) To help increase the strength of the floor by alining the top edges of the joists and to make possible the laying of a finish floor.

(2) When laid diagonally, to stiffen the building, especially when used on second and third floors.

(3) To serve as a working platform during construction operations.

(4) To help deaden sound.

(5) To help prevent dust from rising from the basement to the first floor.

(6) To aid in insulating a room.

5-3. *Types and sizes.* The material used for the subfloor may be 1-inch boards, 4 to 12 inches wide, and usually graded as No. 3 common. The boards may have square edges or may be milled to form shiplap or dressed and matched joints. Plywood, 5/8 inch or thicker, may also be used. Special plywood flooring panels with milled tongue-and-groove edges are now in use, but they are thicker (1 1/8 inch) than most subfloors and are not suitable for repairs on existing floors unless the entire floor is to be replaced.

5-4. Boards used for subflooring are available in standard lengths of 8 through 16 feet. When you are laying subflooring at right angles to floor joists set on 16-inch spacing, considerable lumber can be saved by using lengths of multiples of 4 feet. The common size for plywood panels is 4 x 8 feet, although other lengths in even feet are sometimes available for peculiar requirements. Plywood is extra rigid, is fast to lay, and has a smooth surface.

5-5. *Laying subflooring.* The laying of subflooring, except end-matched boards, will cause considerable cutting, because every joint must be cut to lay on a joist. Two or more diagonal cuts must be made on every board. This cutting takes up time and wastes material. The boards may be laid squarely or diagonally across the joist. If they are laid squarely across the joist, the finished floor can only be laid at a right angle to the subfloor and parallel with the joists. The boards therefore are usually laid diagonally as shown in figure 37, making it possible to run the finished floor in opposite directions in different rooms if desired.

5-6. All subflooring material should be fitted tightly together and nailed with eightpenny nails. Two nails should be used at every bearing point with 4- or 6-inch boards, three nails to every 8-inch board, and four nails to every 10- or 12-inch board. Tongue-and-groove boards are usually toenailed on the tongue edge to draw them up tightly, with the remainder of the nails driven in the face, as shown in figure 38. When nailing plywood sheets, you should space the nails approximately 6 inches apart. Cement-coated nails are often recommended for subflooring because of their greater holding power. They are smaller in diameter than common wire nails of the same size; therefore, they are less likely to cause splitting.

5-7. When a ceramic tile, terrazzo, or mosaic finish floor is to be installed, the top edge of



58

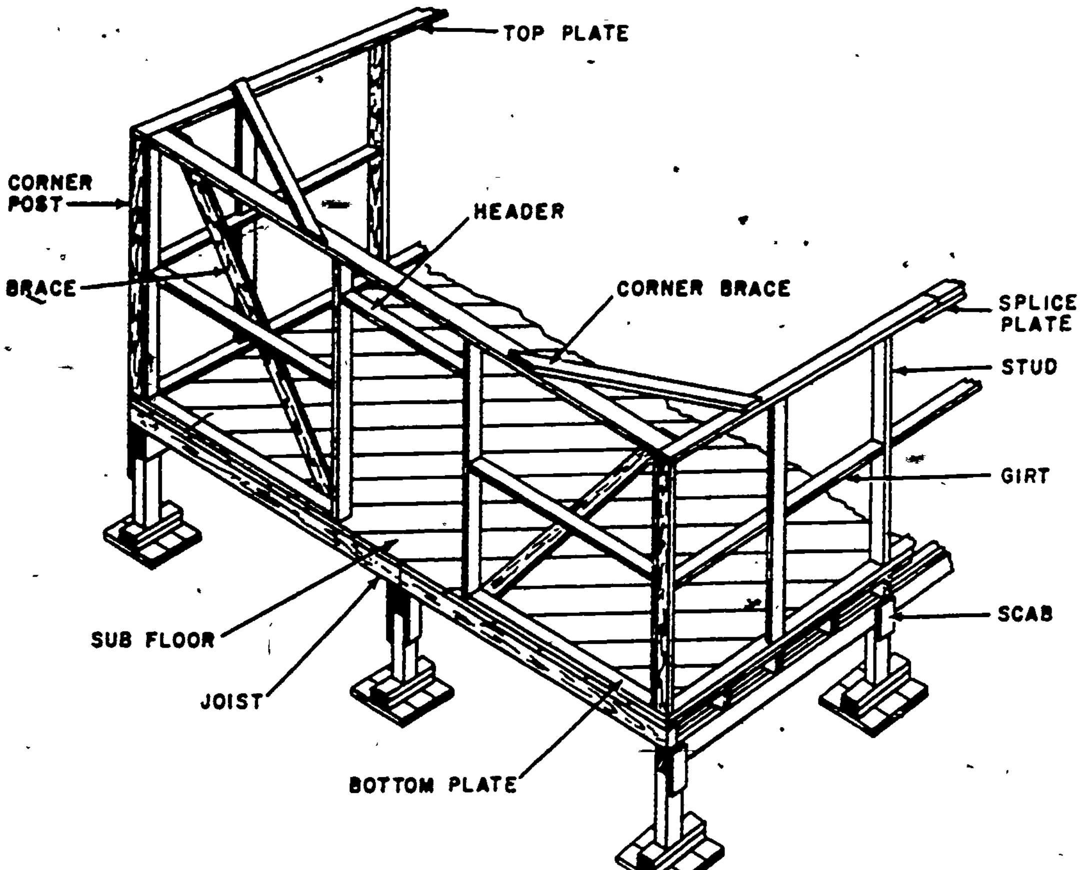



Figure 36. Theater of operations framing.

the joist should be tapered to help prevent cracks in the finished floor. A ledger board (usually 1- x 2-inch material) should be nailed on each side of each joist for supporting the subfloor, as shown in figure 39. The subflooring is cut in short lengths and laid square between the joists.

5-8. **Wall Sheathing.** Some types of wall finish are nailed to the sheathing, rather than the studs, and depend upon this sub or base siding for firm attachment. The sheathing also serves to prevent the movement of air through the wall of buildings and, in this way, insulates, deadens external sounds, and prevents entrance of dirt into the building.

5-9. *Types and sizes.* The material you will use for sheathing may be of any of the 1-inch boards of the types used for subflooring. Plywood is often used because it is strong and is easily and quickly installed. On well-braced frames, you will often use fiberboard, gypsum board, and other specially prepared insulating-type panels.

5-10. *Installing sheathing.* Sheathing may be installed horizontally or diagonally. Diagonal sheathing acts as bracing and is used extensively in areas where high winds are anticipated. Plywood and other materials, which are ordinarily furnished in 4- x 8-foot panels, may be installed either horizontally or vertically. Be sure that you nail the materials adequately with eightpenny nails. The principles and methods discussed concerning cutting and nailing of subflooring also apply to wall sheathing. The sheating will extend over the entire wall frame, from the foundation to the roof and from corner post to corner post, except where openings have been prepared for doors, windows, and other special openings.

5-11 When the wall sheathing has been installed, the doors and windows may be set. If door or window frames are not square and plumb, the doors and windows will not close or open properly. Let's now discuss doors and windows and the methods for installing and maintaining them.

160

## 6. Outside Doors and Windows

6-1. It is probable that you will spend more time in installing and performing maintenance on outside doors and windows than with any other portion of buildings. Their outside location causes them to deteriorate from the effects of the sun, rain, wind, and hail. The wear of day-after-day use and misuse also is reason for continual maintenance. You must, therefore, be thoroughly informed of the proper methods for installing, adjusting, and repairing these important building units.

6-2. If doors and windows are properly installed, a considerable amount of maintenance can be prevented. Also, in addition to the satisfaction given the users of a building, good door and window installations will reduce the costs of heating and cooling.

6-3. Construction of the opening in the wall, or preparing the "rough" frame, is the first step in door or window installation. Accurate measurement, cutting, and nailing of members around the frame opening will make proper installation of the doors and windows much easier and will also assure that they function properly.

6-4. **Wall Frame Openings.** You will remember that in standard construction, wall studs are spaced on 16-inch centers. Therefore, for any opening of greater width than 16 inches, at least one stud will have to be cut. The remaining portions of these cutout studs are called cripple studs. Members, made of stud material, which form the sides of the openings are the

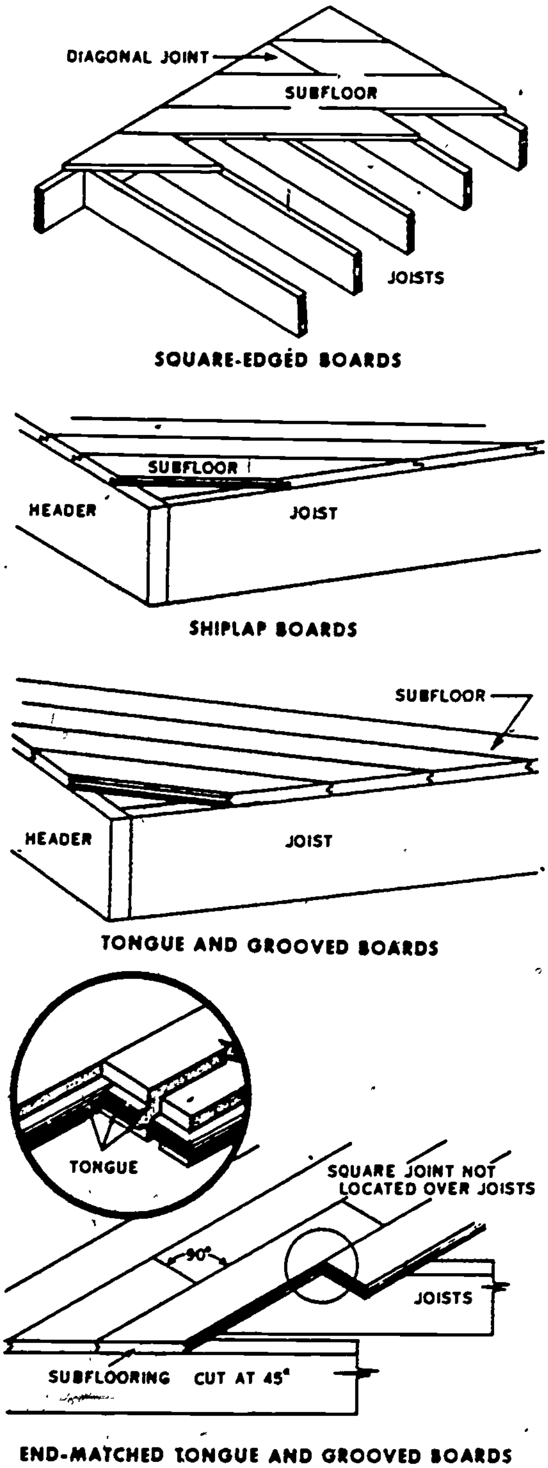



Figure 37. Diagonally laid subflooring.

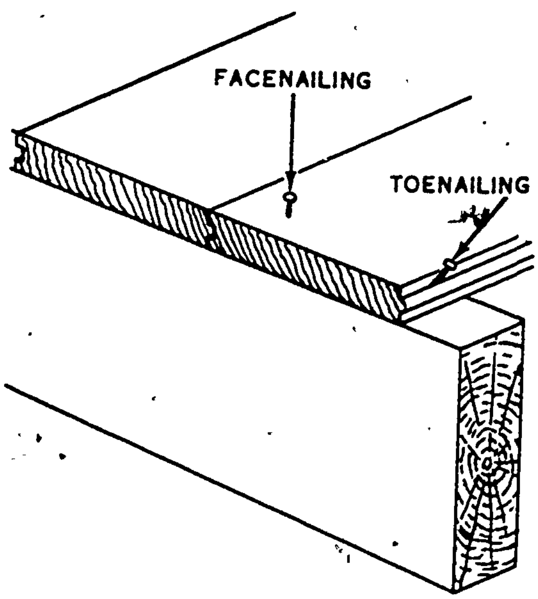



Figure 38. Nailing tongue and groove boards.

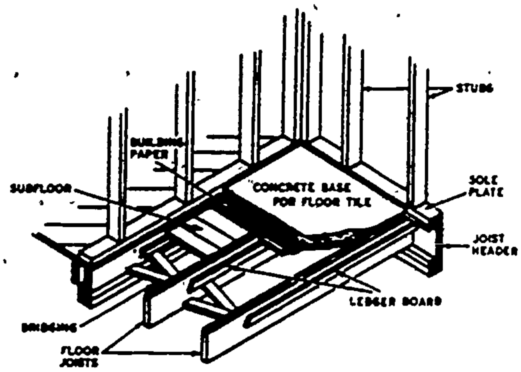



Figure 39. Subfloor for ceramic tile finish floor.

trimmers. Where the side of an opening occurs at a regular stud, this stud may be referred to as a trimmer stud. You will install a header at the top of the opening to support the cripple studs. In the case of window openings, a sub sill is located at the bottom. Several openings for windows illustrating different framing methods which may be used are shown in figure 40.

6-5. Single headers, trimmers, and sub sills, as shown in A of figure 40, may be used where simple single sash windows are used and strength requirements are low. However, these opening framing members are usually doubled, as illustrated in B of figure 40, for installation of the more common types of windows.

6-6. Headers are usually made of stud material and may be installed flat or vertically, as in C of figure 40. Vertically installed headers are stronger but must be spaced with ⅜-inch material. Where the opening is wide, as in D of figure 40, or the load supported is great, you may install vertical headers of 2 x 6, 2 x 8, or heavier materials.

6-7. You will prepare door openings in the same manner as window openings except that the sub sill, if required, will be at floor level. Where a heavy door is to be installed, the trimmers may be tripled on the hinge side, or constructed with materials of greater width like headers.

6-8. Although doubling of opening framing members does strengthen the frame, another important purpose is also served. These members form good backing for nailing of door and window trim. The trim boards are not only for improving the appearance of the building but also for attaching members of the door or window frames.

6-9. After the frame openings have been prepared with their members plumb or level, the

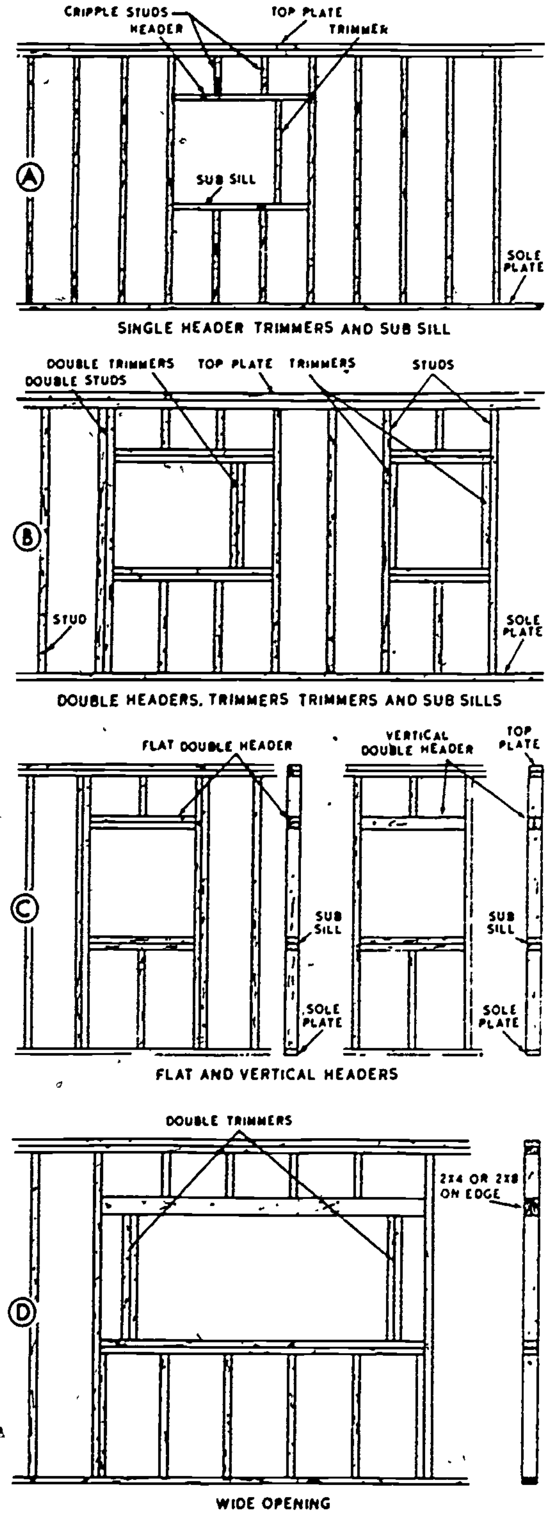



Figure 40. Wall frame openings for windows.

door or window frames may be installed. We will first discuss installation of doors and the procedures for maintaining them.

6-10. **Doors.** There are many kinds of doors in use. They may be classified, according to the way they open and close, as swinging or sliding doors. Doors are also classified by their construction features as batten, solid, panel, or flush types. There are many variations of each type because of the size, strength and ornamental requirements where they are used.

6-11. Batten doors are built of sheathing-type boards which are held together with battens fastened across them as shown in figure 41. You will probably make this type of door on the job. The sheathing boards may be placed either vertically or horizontally. The battens are placed at right angles to the sheathing boards and, in addition, diagonal braces are used to prevent the door from sagging. These doors are used where the openings are odd-sized on sheds or other buildings if appearance is not of major importance.

6-12. Solid doors are made similar to batten doors except that they are fastened and braced internally. They are usually made from materials of the approximate thickness of 2-inch finished boards. The boards are held together with glue and by fastening with dowel pins, splines, or tongue and grooving, as illustrated in figure 42. You may cut these doors in various ways to fit odd-shaped openings. These doors are strong and durable but are quite heavy. Also, they are subject to warping unless they are well made, because there are no bracing members spanning the width of the door.

6-13. Panel doors are probably the most commonly used. They are made up of stiles (vertical members), rails (cross members), and panels. The number and shape of the panels vary considerably, as shown in figure 43. Any of the panels may be of either wood or glass.

6-14. Flush doors are perhaps the most desirable for present-day construction. These doors have either a solid core built up of soft wood or a hollow core made up of grids as illustrated in figure 44. The core usually has stiles and rails similar to those in a panel door. Plywood is laid over the core to provide a smooth surface on each side. The edges of these doors are covered with the same type of wood as the side surfaces. Advantages of this type of door are that they may economically be made to resemble more expensive and massive doors, yet are relatively light in weight and easy to support by the hinges.

6-15. Regardless of the type of door to be used, it will usually be necessary for you to prepare or install a door frame within the "rough" opening. Properly installing the door frame is another step in making door fitting easier and in reducing future maintenance.

6-16. *Door frames.* Although all door frames include certain parts, the details of each part can vary. The door frame is made up of two side jambs, a head jamb, an outside casing, and a sill, as shown in figure 45. The drip cap and inside casing are sometimes included as parts of the door frame. These parts will be discussed with exterior and interior wall finishing (see Section 7 of this chapter and Chapter 4, respectively).

6-17. Door frames may be purchased commercially as units, or you may build them in the local carpentry shop. Frames purchased may be assembled and ready for installation, or they may be in knocked down (K.D.) bundles which you will put together on the job.

6-18. A construction detail which is peculiar to external door frames is the way in which the jamb is rabbeted. Figure 46 illustrates the ⅜-inch by thickness-of-the-door rabbet which is provided to form a stop for the door to close against. When you are ordering or making a frame for an external door, the thickness of the door must be considered as well as the height and width of the door and the thickness of the wall.

6-19. When the door frames are delivered, they should be given a prime coating of paint to keep out moisture and prevent warping. Before you set a door frame, square and brace it. The

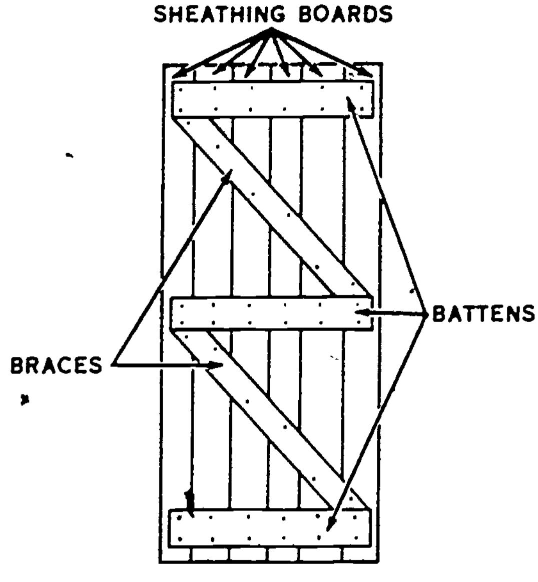



Figure 41. Batten door.

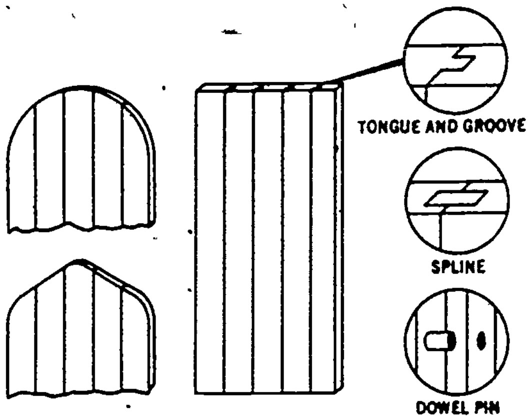



Figure 42. Solid doors.

bracing is important, especially if the frame is to be handled much before setting. Before placing a door frame in the rough opening, check the various dimensions of the frame and compare them with the dimensions of the rough opening. Tack a strip of heavy building paper 10 to 12 inches wide against the sheathing around the rough wall opening. Set the door frame in place and adjust it by using wedge-shaped blocks at each side and bottom, as shown in figure 47. Adjust the frame at the bottom and at the ends so that spacing between the frame and the rough opening is the same on both sides. An 8d finishing nail driven through the casing into the wall at the bottom of each side will hold the frame in place. When you fasten the frame in position, do not drive the nails completely into the wood until you place all nails and make a final check to determine if readjustment is necessary. Check both sides of the frame by placing a level against the inside edge of the casing. This will show whether the frame is plumb. A nail driven through the casing near the top on each side will then hold the frame in position. After fastening the frame at the top, make a second check to insure that the sides are plumb and the head jamb is level. When the sides are plumb and the top is level, all the corners of the frame should be square. Finally, securely fasten the frame with 8d finishing nails placed ¾ inch in from the outer edge of the casing and spaced 16 inches apart. Set all nails below the surface of the wood.

6-20. Whereas materials used in the jambs discussed above are for swinging doors, ordinary finished board of width the same as the thickness of the wall is used for overhead and other sliding doors. These doors are ordinarily closed against the inside or outside casing and therefore do not require a stop on the jamb.

6-21. Now, with a good understanding of the framing methods for external doors, you are ready to learn how to hang or install the doors.

6-22. *Swinging doors*. Doors which swing to open and close are used in two general areas. First, on sheds or other storage buildings of a temporary nature, batten-type doors are often installed, using strap or T-hinges. Although you should build these doors accurately, the tolerances for fitting them to the frame are relatively large. Larger fitting tolerances are acceptable, because the passage of air around the door is not so objectionable in the areas where they are used. However, you should not use this as an excuse for poor workmanship. When you are hanging these doors, select hinges of sufficient strength and nail or bolt them to the door at the location of the battens. Then locate and support the door in the opening with the upper end of the diagonal braces on the hinge side. With the door properly positioned, securely fasten the other side of the hinge to the door frame. These doors are usually held closed by the use of some type of hinged hasp.

6-23. Second, swinging doors are the con-

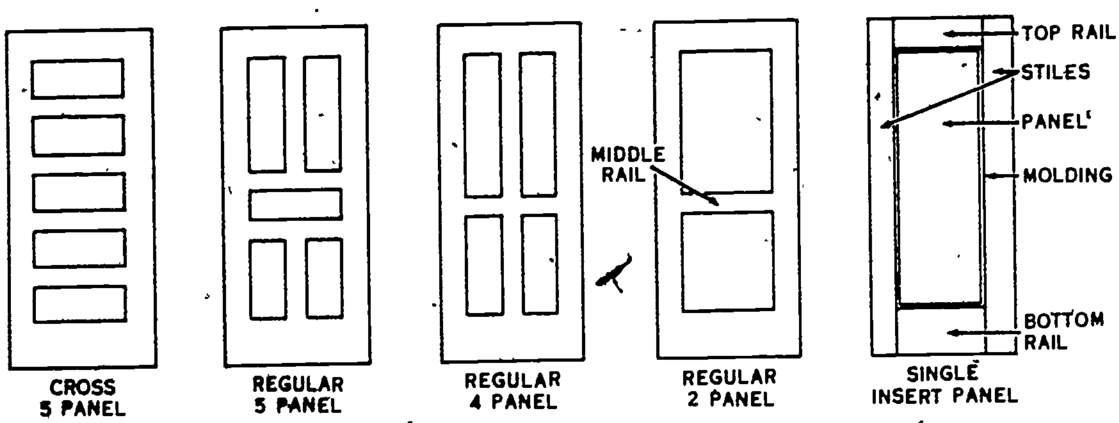



Figure 43. Panel doors.

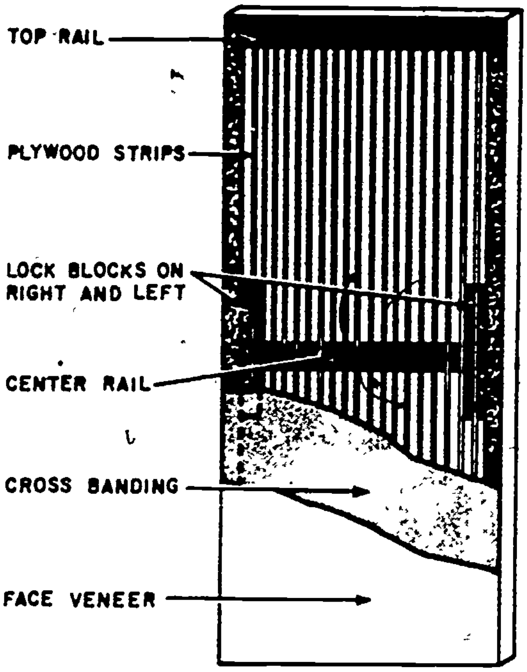



Figure 44. Flush door.

ventional type used in houses, offices, and other structures where it is desirable to control the temperature, humidity, or cleanliness of the air. Panel- and flush-type doors are most often used in these areas, but solid doors may occasionally be installed. Usually mortised hinges are used when hanging these doors, as they allow closer fitting of the door to the frame. Locks and latches of various types may be used. Because the installation procedure for these doors in external walls is the same as for inside doors, we will complete our discussion in Chapter 4, where interior finishing is explained.

6-24. *Sliding doors.* In many warehouses, supply points, and shop areas, space is not available for opening swinging doors or the weight of large doors cannot be successfully supported by hinges. Where these conditions exist, sliding doors will frequently be selected for use. Sliding doors actually open and close by rolling rather than sliding, for they are supported by and operate on channels and rollers. These doors may be of two general types, according to the direction of movement: horizontal and vertical.

6-25. Horizontal sliding doors are usually of batten or solid construction. You will install the roller assembly to the top of the door and the channel to the door frame with bolts or lag screws. The location of the channels determines the approximate clearance between the bottom of the door and the floor. However, you can make final vertical adjustments on the bolt of the roller assembly. Guide channels or posts must be installed at the bottom of the door, and stops must be provided at the end of the roller channels to establish the open and closed positions. These doors may be installed on either the outside or the inside of the door frame. When you make an external installation, a drip cap should be mounted over the channel to prevent moisture from entering the building at the top of the door. A double sliding door installation is shown in figure 48.

6-26. Vertical sliding doors are better known as overhead doors, since they are in an "overhead" position when they are open. You will install overhead doors in areas where the conditions are similar to those discussed for horizontal sliding doors. Where an overhead installation is possible, a more weatherproof fitting can be made than with a horizontal sliding door.

6-27. Overhead door hardware is available in so many varieties that we will not attempt to discuss all of them here. Let's look at representative examples of this hardware so that you can learn to install, adjust, and maintain them.

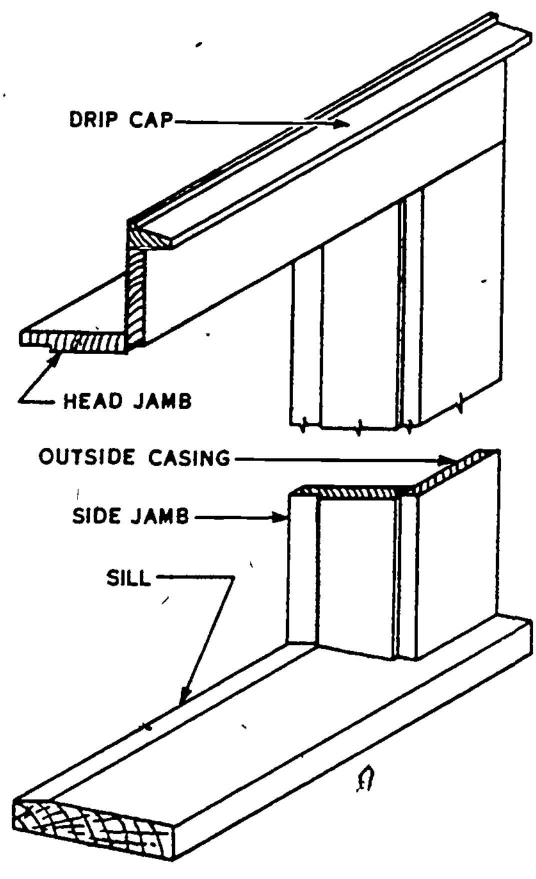



Figure 45. Exterior door frame.

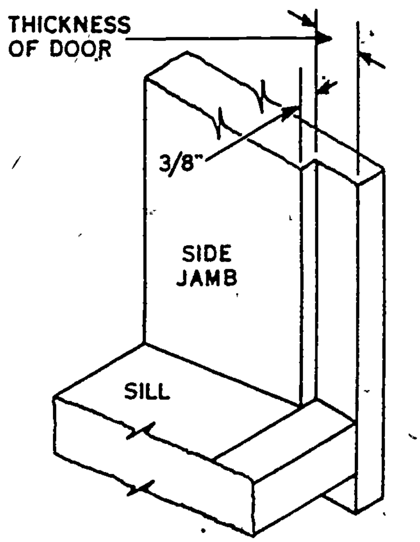



Figure 46. Rabbet in external door jamb.

6-28. One example of the spring balance system used to control the weight of overhead doors is shown in figure 49. This system allows the use of weather stripping along the bottom of the door, and on the door and door stop along the sides of the door. You will use this type of hardware where solid or single section doors are to be installed. The balance springs, one on each side of the door, are intended to assist

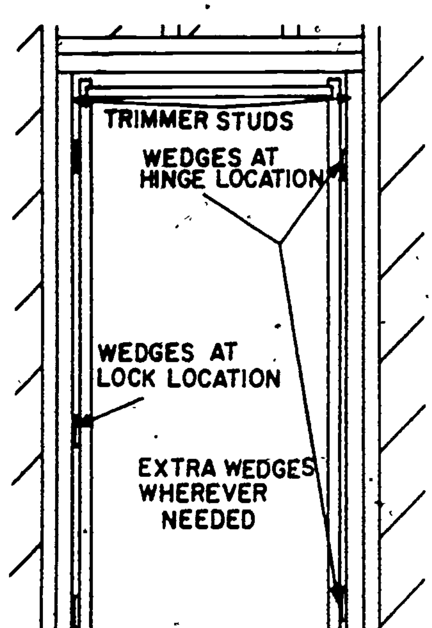



Figure 47. Adjusting door frame.

in lifting the door from the closed position and to control the weight of the door as the door is being closed. Tensions on the springs are adjusted with the mounting bolts and nuts located at the lower end of the springs. Each spring must carry its share of the load, or the top of the door will bind on the door stop or against the overhead channels. You can check the spring adjustment by raising the bottom of the door about 3 feet and releasing it. If the springs hold the door in position or lift it higher, there is sufficient tension on the springs. If the door drops back to the closed position, you should increase the tension on the springs by tightening the nuts on the adjusting bolts. Check the adjustment again. If the door rises and strikes the

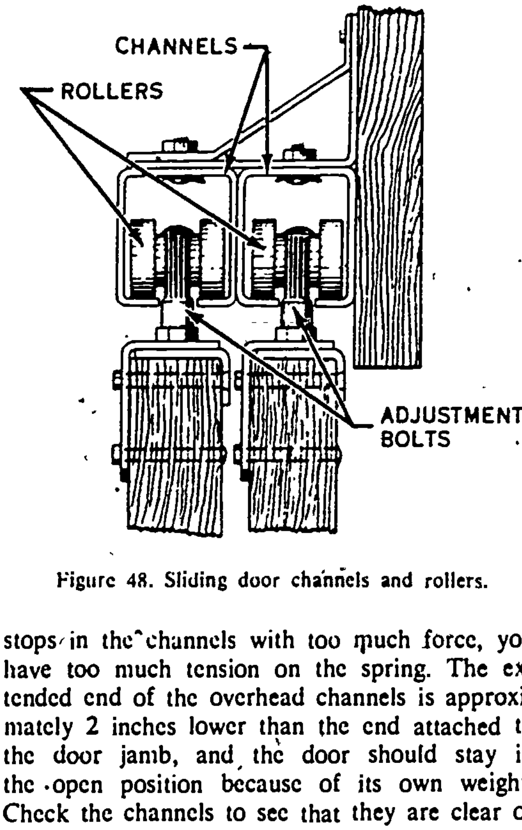



Figure 48. Sliding door channels and rollers.

stops in the channels with too much force, you have too much tension on the spring. The extended end of the overhead channels is approximately 2 inches lower than the end attached to the door jamb, and the door should stay in the open position because of its own weight. Check the channels to see that they are clear of obstructions and that all hangers are secure.

6-29. Another example of a spring balance system for overhead doors is shown in figure 50. This system is used mostly on doors that are constructed in sections and hinged together. Each horizontal door section has a roller on each end to guide it in the side and overhead channels. This type of door does not swing outward when it is raised, but follows the path of the channels. The balance system consists of springs (mounted above each channel), pulleys, and cables. The cables are fastened with pins

166

and links to the bottom section of the door. Each cable runs through a pulley mounted at the top of the jamb, through a second pulley attached to the end of the spring, and back to a bracket above the door jamb. The cable is fastened to the bracket with a looped system, as shown in figure 50, A, that prevents it from slipping. Don't tie a knot in the cable at this point, because this is where you adjust the tension on the spring.

6-30. The greatest tension is on the spring when the door is in the closed position, so don't attempt to adjust the cable or spring with the door closed. Raise the door to the open position and block it in place with 2 x 6's placed beneath the bottom of the door so that they extend along each jamb. This should take almost all the tension off the spring, and you can notice the cable and spring sag out of line. It should be safe to loosen the cable in the bracket and make the required adjustment. Don't remove the loops of cable from the bracket unless you need to replace the cable or pulleys. Keep the cable through the holes and pull more cable through to add tension to the spring. Make necessary adjustments to the channels after the door is returned to the closed position.

6-31. Good installation procedures will prevent a large amount of door maintenance. However, even when installation has been correct, doors will from time to time require adjustments, repair, replacement, and other types of maintenance because of deterioration, wear, or misuse.

6-32. *Door maintenance*. Maintenance of doors and frames can be of many kinds. We will discuss those malfunctions which you will most likely be required to locate and correct.

6-33. Replacing doors may seem to be a never-ending requirement in the field of maintenance. Whenever a door is broken or decayed beyond reasonable repair, a new one must be installed. The replacement process is similar to the original installation. Removal of the old door is a simple process of removing screws or bolts and any hinges or locks which may be reusable. The door must be examined for style and type of material and measured for size so that the same kind of door (or suitable substitute) can be built or ordered.

6-34. In some cases, doors may be repairable. Batten doors may require replacement of boards. This can often be done on the job location. Repair of solid and flush doors, and panel door stiles, rails, and panels will be attempted only in shops where necessary woodworking tools are available.

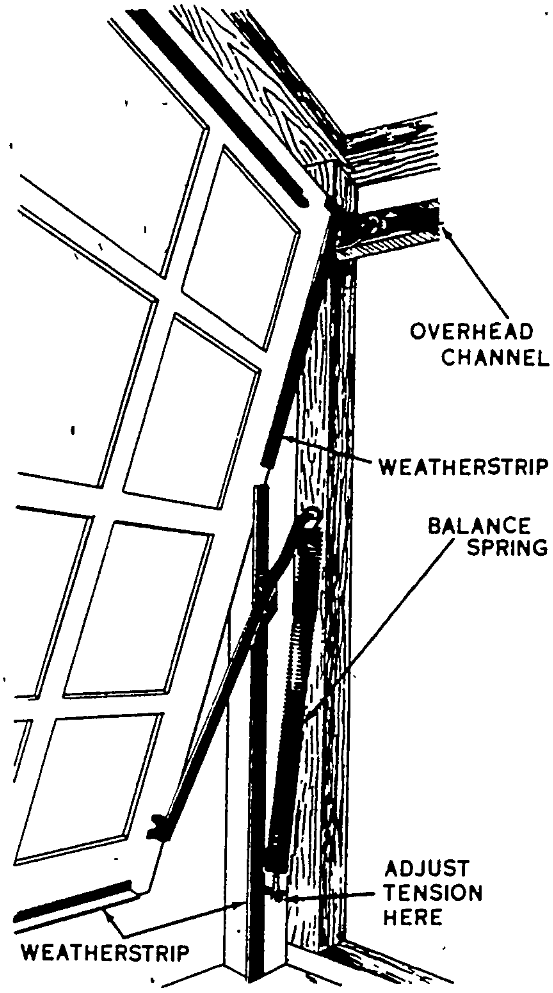



Figure 49. Spring balance overhead door installation.

6-35. You may restore a warped door to its normal shape by removing it and laying it flat. Weighting down may also be necessary. If it is still warped after a reasonable length of time, battens (strips) screwed to the door will help restore it to a true plane. Screw eyes, rods, and turnbuckles will help straighten a door by gradually pulling it into place.

6-36. Install a diagonal batten from the top of the hinge side to the bottom of the lock stile to repair a sagging door permanently. Temporary repair is made by installing a diagonal wire stay brace equipped with turnbuckles.

6-37. Many outside doors have panels of glass. These glass panels are replaced, when broken, in the same way that broken windows are repaired. This procedure will be discussed in detail in a later section of this chapter.

6-38. Also, there are many adjustments which may be made on the hinges and locks

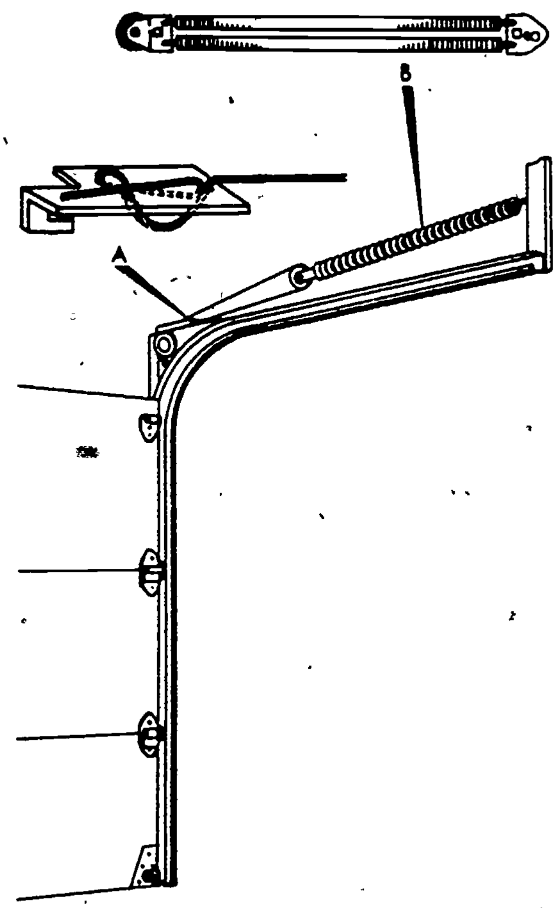



Figure 50. Spring and cable controls for overhead doors.

of panel and flush door installations. These adjustments will be explained when we discuss the maintenance of interior doors in Chapter 4.

6-39. Work on spring-controlled equipment, such as overhead doors, can be done best when at least two men are on the job. Working alone, you could work yourself into some embarrassing, if not fatal, situations when trying to adjust channels or spring tension.

6-40. Maintenance of overhead doors will usually consist of readjusting springs and mounting bolts according to the procedures which you have learned for installing these doors. However, there may be times when overhead doors are repaired by covering them on the outside with exterior grade plywood. The single pair of springs will not control this added weight. True, you can make adjustments that will compensate for the weight for a short length of time, but these adjustments are neither dependable nor safe. The solution is to replace the single springs with double springs arranged as shown in figure 50,B. Make the necessary adjustments with the cable to correctly control the door.

6-41. A single new spring can be added beside each of the old springs if you don't have the hardware to make the double set as illustrated in figure 50,B. A new spring will be shorter than the used, expanded old spring. If you attach them to the same bracket, the new (shorter) spring will carry all the load, and the old (longer) spring will just sag in place. You can compensate for this by using an 18- to 24-inch length of chain (heavy 1-inch links) to extend the length of the new spring to equal the length of the old one. Adjustments can be made occasionally by taking up another link of chain to make both old and new springs perform equal parts of the work.

6-42. If door frames become damaged or decayed, replacement may be required. The jambs are particularly subject to damage. The weight of the door on the hinges often will split the jamb where the hinges are fastened. Also, breakage of the jamb where locks and latches are located is likely. When you replace a jamb, you must make measurements carefully to assure that the door will fit the repaired frame. Remember that the jamb must be rabbeted to the thickness of the door. Fitting of the frame can be done by using blocks and shims behind the frame.

6-43. In some cases when you are are installing doors, you can make a better seal at the edges by installing weatherstripping. However, this material is more frequently used to improve the weatherproof qualities of older door installations. Weatherstripping of several different types is available. Generally, you will use one of the following materials: metal, felt, or rubber (or rubberlike plastic). You will install metal weatherstripping on the side of the rabbet of the door jamb to form a seal with the edge of the closed door. The felt and rubber materials are soft or spongy and are fastened to the door jamb or casing so that the face of the door may close against them to form an airtight seal.

6-44. Now that you have a good understanding of the procedures for installing doors and are prepared to perform maintenance on them, we will consider the methods and problems of installing and maintaining windows.

6-45. **Windows.** Windows should prevent the movement of air around them when closed, yet they should operate with ease when opened for ventilation. If you do not install them carefully, they will be either too loose or too tight. Study the following paragraphs and you will have little difficulty in making good window installations and repairs.

6-46. Although windows may be of many kinds, they are of two general types: double-hung and casement sash. The double-hung sash moves up and down, whereas the casement sash is hinged at the side. Like doors, windows have two main parts—the frame and the sash. The window frame finishes the wall opening and holds the sash, which contains the glass and which may be moved for opening and closing.

6-47. *Double-hung frames.* The construction of a double-hung window frame is illustrated in figure 51. A jamb is ¾ inch thick and has a parting strip to separate the top from the bottom sash. The outside casings are of the same thickness and width as door casings. These windows, when installed separately or in pairs or triples, must have a space on either side of the window to permit operation of the sash-balancing mechanism. Some type of sash-balancing device is necessary on double-hung windows because the upper sash will not normally stay closed and the lower sash will not stay open. The balancing device assists in holding the sash open, closed, or in any other desired position.

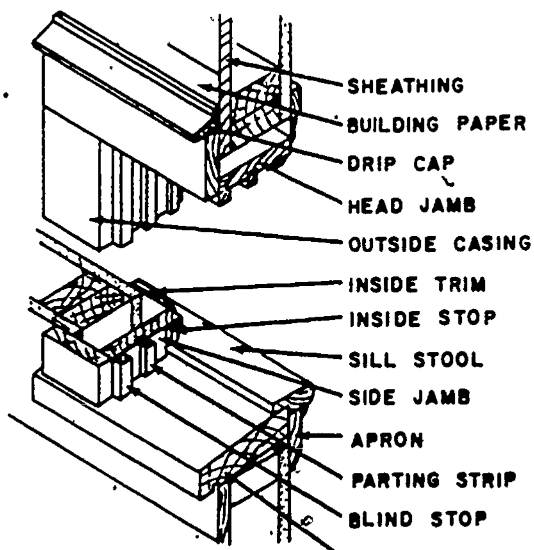



Figure 51. Double hung window frame.

6-48. Perhaps the oldest and most commonly used balancing device is a pulley and weight arrangement. With this device, a pulley is installed near the top of each side jamb, and a cord is run over the pulley. One end of the cord is fastened to metal sash weights, and the other end is fastened in a groove on the edge of the sash, as shown in figure 52.

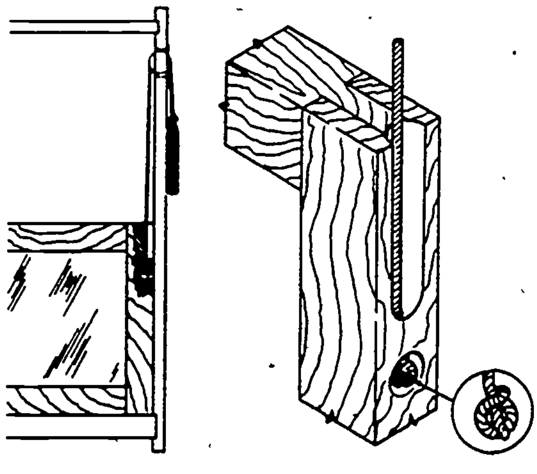


Figure 52. Pulley and sash weight arrangement.

6-49. There are several spring and friction types of balancing devices in use. One of these types which you will very likely install or repair is the spring and tube holding device. This device uses a spiral spring in a tube, as illustrated in figure 53. The edge of the sash is grooved to fit over the tube. The spring is fastened to the top of the tube and to the top of the sash. The tension on the spring holds the sash in any desired position.

6-50. Spring-loaded pins, as shown in figure 54, are another common type of holding device. Although less expensive than other holding devices, they are less desirable because the sash can be placed only in certain fixed positions.

6-51. *Casement sash frames.* The construction and thickness of materials of the casement

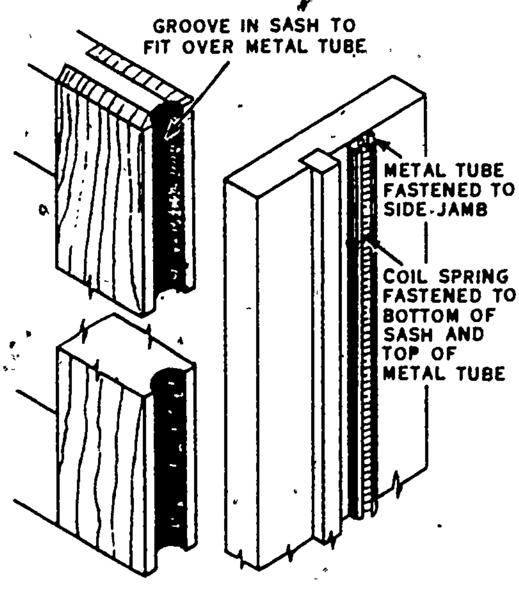



Figure 53. Spring and tube holding device.

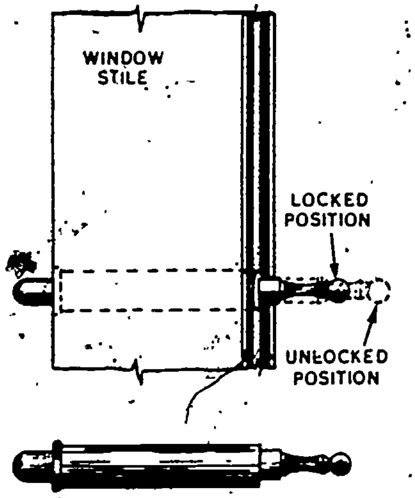



Figure 58. Spring loaded pin-type holding device

sash frame are similar to those of the outside door frame. The sash is hung on hinges and may swing either inward or outward. Because of the requirement for close fitting of the sash to the frame, mortise-type hinges and locks are used. Stops on the jambs, to provide a surface for the sash to close against, may be provided by installing strips of wood or by rabbeting the jamb edge. A typical casement sash window is shown in figure 55.

6-52. Casement sash windows are more economical to install than double-hung windows and are therefore used in many temporary buildings. Where opening of the window is not necessary, the sash may be held in place by molding rather than hinges. In many locations, however, casement sash windows are undesirable because they are difficult to keep weathertight. Additional problems are encountered when you are installing window screens; if the sash swings out, the screen must be located on the inside of the window. Whether the sash be double hung or hinged, the same general procedures are used for installing the frame.

6-53. *Window installation.* Similar methods are used in setting window and door frames. As with door frames, when the normally preassembled window frames arrive at the site, you should be sure they are given a prime coat of paint. When the frame is ready to set, the dimensions of the window frame should correspond to the dimensions of the rough opening. A space of at least 2¼ inches must be left on each side of the frame between the jamb and the stud of the rough opening to allow for frame adjustment and free movement of the sash weight. A casement-sash window has no weights, so it requires only a ½-inch space. A strip of heavy building paper 10 to 12 inches wide should be placed around the rough wall opening. The frame is set in the rough opening and held in place by tacking one end of a temporary brace to the side of the jamb near the top with the other end of the brace tacked to a block of wood nailed to the floor. Wedge-shaped blocks are placed under the sill to adjust the frame to the correct height. Remember, there should be a spacing of 2¼ inches between the jamb and the rough opening for double-hung frames. The leveling of the sill is accomplished by placing blocks at points near the outside jambs. The frame is held in position by nails placed near the bottom on each side. Both side jambs should be checked for plumbness with a carpenter's level. Now the entire frame should be checked with a carpenter's level to make sure that all sides of the window are plumb and that the sill is straight and level. When checks reveal that the frame is plumb, it is nailed securely in place against the wall with 8d finishing nails spaced 16 inches apart and ¾ inch from the outside edge of the casings.

6-54. If your assignment as a carpenter is a normal or average one, it is probable that you will spend more time in performing maintenance on windows than in installing them. Your understanding of windows and the procedures for installing them will, however, prove valuable to you in performing repair and replacement.

6-55. *Window maintenance.* Windows have

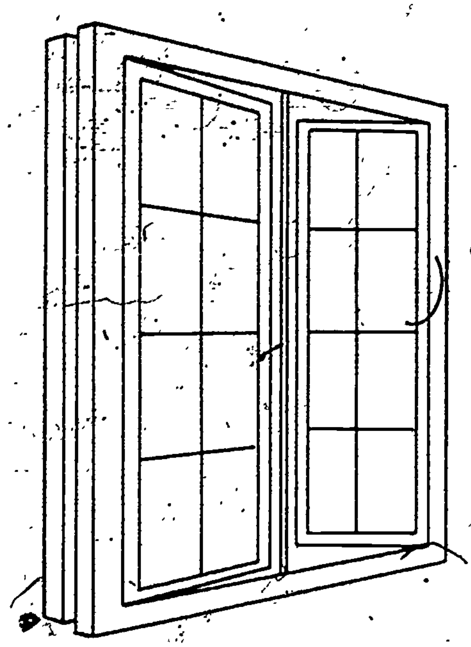


Figure 55. Casement sash window frame.

many of the same maintenance requirements as doors. Casement windows are hinged and are fastened in the closed position with a barrel bolt, hook and eye, etc. The jamb, casing, header, and drip cap will have the same defects as those found on doors. The double-hung window may prove to have some different problems.

6-56. The double-hung window has a top and a bottom sash that slide up and down between the stops in the jamb. It may be necessary at times to loosen the sash from the stops by inserting the blade of a putty knife between them. A hammer and block may be used (gently) to loosen the paint if there is insufficient room to insert the putty knife. When the sash is an old one, extra care must be taken to prevent breaking the glass.

6-57. One of the main differences in window construction and that of doors is the use of the sill, stool, and apron. When replacement of the sill is required, the window is removed as a section. Removal of the apron, stool, and inside casing is necessary to allow the window unit to be removed from the outside. Loosening the nails along the outer edge of the outside casing will allow the jamb to be removed easily. Check the jamb to see if nails have been driven through it and into the studs. There should be no more than two nails in the jamb. One nail at each end of the head jamb is more than sufficient to hold the jamb in place. There is usually one nail through each end of the sill that holds the bottom of the jam in place. Don't be surprised if there are no nails in the jamb. Once you remove the inside casing, the jamb may be free to fall out of the opening. This method is sometimes used to allow the jamb to be as free and straight as possible without wedging and nailing, which (as time passes) may cause the jamb to spread at the top and bottom. Replace the sill with a new one and install the unit. Wedging is required on the top and bottom at the ends of the side jamb. Proper wedging will hold the window square and level until the casings are fastened.

6-58. Maintenance on double-hung windows usually consists of adjusting hardware or loosening the sash in the jamb. Some of the common faults and their remedies are listed below:

- Binding sash along stops—Wax the surfaces that bind. If this does not remedy the situation, remove the stop and plane a small amount from the side of contact. Sanding or scraping may be easier than planing if binding is not great.
- Binding due to swelling of the sash—If the swelling is due to moisture and the sash will work properly when dry, leave it alone. Do not plane the sash unless it is necessary. If the sash is too large to slide properly, remove it by removing the stops, and plane it as required.
- Bowing of stops—Remove stop and cut off the end to the proper length.
- Broken sash cord—Broken or missing cords call for careful removal of the stop on one side of the jamb. Remove one edge of the bottom sash at a time and remove remaining sash cords from sash. Tie a knot in the cord that will prevent it from being drawn through the jamb. Remove the parting stop and top sash, using the same precautions. Replace the cords with proper length of new cord. Cords that are too long or too short will not work properly. If the weight balance has dropped within the wall, it may be necessary to remove the inside casing to locate it and replace the cord. Barrel bolts or other devices are sometimes used in place of the cord and balance system.
- Malfunction of springs—Check attachment of control springs or friction devices. These may require reinstallation. Follow manufacturer's instructions for adjusting holders, springs, or other parts of particular types of devices. A special tool, which is furnished when certain windows or devices are purchased, may be required in making some adjustments.

6-59. *Glass replacement.* No discussion of windows would be complete without considering the installation or replacement of glass. Although most new sash are delivered with the glass installed, the procedures for replacing glass are the same as for installing it except that you must clean the old sash. Cleaning the sash of old putty and installing new glass and putty can be a challenging job. The better job you do in scraping the putty from the sash, the easier you can apply the new putty. Perhaps you have wondered why some people make the job appear difficult, whereas others seem to get a neat layer of putty the first time their knife slides along the sash.

6-60. Practice is an essential part of learning to cut and install glass. An understanding of the basic techniques can save you a lot of time and effort. The main tools that you will need are a glass cutter with extra wheels, a common screwdriver 4 to 6 inches long, a clawhammer, a wood chisel ½ to 1 inch wide, a putty knife with a 1-inch-wide blade, and a framing square or straightedge.

6-61. Putty for wood sash may be either Type I or II. Types I and II may be used interchangeably, but Type II is recommended for filling holes and cracks where a hard material is desirable. Types I and II are both suitable for



170

70

interior and exterior work. Type I is an elastic glazing compound which dries on the surface but remains slightly soft and plastic underneath. It is recommended for use where repeated shock or vibration may be encountered. Putty should be stocked in small quantities (30-day supply) so that it will be fresh and pliable when used.

6-62. One gallon of putty will normally bed and face glaze approximately 100 linear feet of ¾-inch rabbet, 150 linear feet of ½-inch rabbet, or 200 linear feet of ⅜-inch rabbet. One gallon of putty could be used to install approximately 65 8- x 10-inch windows, where a ⅜-inch rabbet is used on the sash.

6-63. Glazier points, as shown in figure 56, are used to secure the glass in wood sash. The triangle is driven with a hammer and the edge of a screwdriver or wood chisel, etc. Everyone works out his own method, but the side of a chisel or screwdriver blade usually works best. The points are driven in flush along the glass as shown in figure 57 and are driven below the height of the rabbet on the opposite side of the glass. A gun is used to drive the diamond-shaped point, and the T-shaped point is driven with the blade of a screwdriver.

6-64. Clear window glass, Type II A quality, is recommended for replacements in hospital and administrative-type buildings. The use of B quality glass in quarters and service buildings will afford a saving in the costs of material. The following schedule may be used as a guide for selecting the thickness and sizes of installed clear window glass.

- Single-strength—up to 400 sq. in.
- Double-strength—over 400 sq. in. to 7 sq. ft.
- $\frac{3}{16}$-inch-thick—over 7 sq. ft. where glass is required.

6-65. Wire glass, Type III, is made in two forms: flat and corrugated. Flat wire glass, usually ¼ inch thick, in used in doors, windows, fixed side wall sash, and skylights. Corrugated wire glass, $\frac{5}{16}$ inch or more in thickness, is used mostly in skylights. Clear, flat wire glass, polished two sides, is used in windows and doors of detention, storage, and other buildings where security and clear vision are necessary. Figured or ribbed glass smooth on one side is desirable for use in doors and windows of buildings such

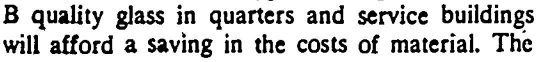


Figure 56. Glazier points.

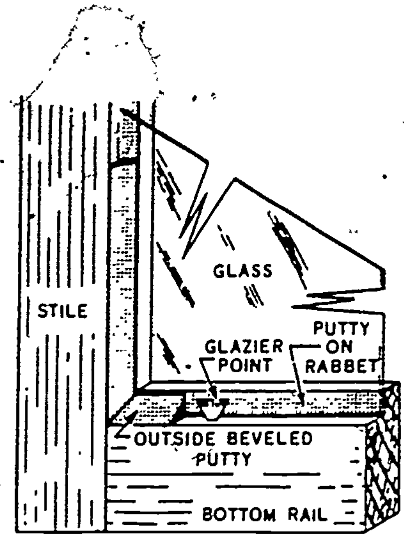



Figure 57. Glass installed in wood sash.

as shops, garages, and warehouses where clear vision is not required. Two systems of skylight construction, puttied and puttyless with flat or corrugated glass, are used to light building interiors. Skylights made up of multiple supporting members and glass lights are often a source of leakage. As a rule, maintenance work will consists only of replacing sealing strips, cushion strips or compound at joints between glass sheets. More extensive repairs may consist of replacement of glass, metal flashings, and joint cappings, alll of which will be performed with similiar materials and in the same manner as for the original installation.

6-66. Obscure glass, Type III, glazing quality, rolled figure on one side, smooth on the opposite side, and not less than ⅛ inch thick, is used where clear vision is not necessary or is undesirable. Such locations would include windows and doors in toilets, baths, dressing rooms, operating rooms, surgical dressing rooms, prophylaxis and mortuary rooms, shops, garages, and warehouses.

6-67. Heat-absorbing glass, Type VI, clear, is installed in the sash of control towers and other spaces where occupants are exposed to direct or reflected rays of the sun. This glass is generally ¼ inch thick, clear, ground, and polished. Where clear vision is not required, use the rolled figured, blue-green, obscure glass.

6-68. Light-diffusing glass, Type III, Pattern VI, is usually not less than ¼ inch thick. Surface design may be a series of cylindrically shaped lenses on each side of the glass with the lenses on one side running at right angles to the other. An alternate design is a series of parallel rows of circular lenses on each side, with the centers of the lenses on one side half way between centers of lenses on the opposite side. Depending on the manufacturer's standards, circular lenses may be spaced ¼ or ½ inch on centers This lens-type glass is especially desirable for use in borrowed light partitions and in spaces where an even distribution of light in all parts of the room is necessary.

6-69. Colored glass, Type III C, acceptable for use in exterior sash of chapels. is a hammered or figured pattern sheet not less than ⅛ inch thick. Generally, it is amber in color, but several other colors are also available.

6-70. Shatterproof glass is installed to advantage in observation windows in engine test rooms, detention rooms, and other places requiring a high resistance to breakage. Glass may be tempered or laminated. not less than ¼ inch thick. and polished on both sides.

6-71. Tempered glass is made by reheating glass until it is somewhat soft, then cooling it quickly in a bath of oil or against a metallic surface. It will withstand heavy impacts and great pressures, but a comparatively light blow with a pointed object on or near the edge may break it. This type of glass may fly apart violently when broken.

6-72. Laminated glass gives protection against flying pieces of broken glass. This glass is built up in the manner of a sandwich with a sheet of transparent adhesive bonded between two sheets of glass. If a break occurs, the plastic stretches, serves as a cushion. and also holds the sharp fragments together.

6-73. When a glass is broken, cracked in such a manner that the pieces may fall out, or is a safety hazard, it is time for replacement. The following information should be of help in planning the job.

6-74. Glass should be purchased and stocked in sizes that can be used without cutting. Glass of special sizes may be cut on a table in the shop. The correct glass size is obtained by measuring the sash and deducting $\frac{1}{16}$ to ⅛ inch for irregularities in the sash. If you set up a table in the shop, it should be perfectly smooth, be about 4 feet square, and have the front and left-hand end square. Mark off the table surface in inches with a T-square and keep the T-square around to use for a straightedge when cutting the glass.

6-75. The glass should be given a thin coating of turpentine or kerosene along the cutting line. Use a sharp cutter and draw the cutter along the cutting line only once. Additional strokes with the cutter may break the glass, and it doesn't help the cutting wheel. Slide the glass so that the cut line is just beyond the edge of the table. Keep a firm grip on the excess that is to be cut off to prevent it from accidentally breaking off. Tap the glass under the cutting line from the edges towards the middle. As you tap, you can see the glass break through beneath the mark made by the cutter. Small fragments that do not break properly can usually be removed by using the notches on the back side of the cutter. Use goggles. gloves, and apron while cutting the glass. Small particles left on the table should be removed with a brush.

6-76. Replacing the glass in an old wood sash involves a little more work then the initial installation. Clean all putty runs (rabbets) by removing broken glass. putty, and glazier points. Paint and putty can best be removed by scraping. The putty runs should be brushed out, cleaned with mineral sprits or turpentine. and allowed to dry. If the sash is extremely dry (very porous). a coating of linseed oil or primer paint should be applied before the putty to help to keep it in a plastic form. Do not glaze or reglaze exterior sash when the temperature is 40° F. or lower, unless the work is absolutely necessary.

6-77. Before the new glass is placed in the sash. you should put $\frac{1}{16}$ inch of putty along the back edge of the rabbet. Place the glass on this layer and apply a slight amount of pressure along the edges to cause the putty to spread into a smooth layer. This putty bed forms a weather-tight seal on the inside of the sash. Place glazier points about 2 inches from each corner and about 6 inches apart along the putty run to hold the glass firmly in place. After the points are in place, a continuous bead of putty is run along the perimeter of the glass face and putty run. Press the putty with a putty knife, using sufficient pressure to insure complete adhesion to the glass and sash. as shown in figure 58. Finish the surface with full, smooth, accurately formed bevels with clean-cut miters. Trim the bed putty that pushes out on the reverse side of the glass.

6-78. **Window and Door Screens.** In most climates and geographical areas, buildings which are used primarily for housing personnel (for either residence or work) are provided with screens to cover the windows and doors. These screens serve to prevent entry of insects and to protect the glass from breakage. The screens are built on a frame so that they may be installed and removed separately as desired. The frames are made to fit into the outside casings of the window or door, as shown in figure 59. Similar materials are used in door and window screens, except that the screen door frames are usually heavier and stronger. An additional use of screens is in inclosing porches. In these cases. a special framework is constructed to hold the

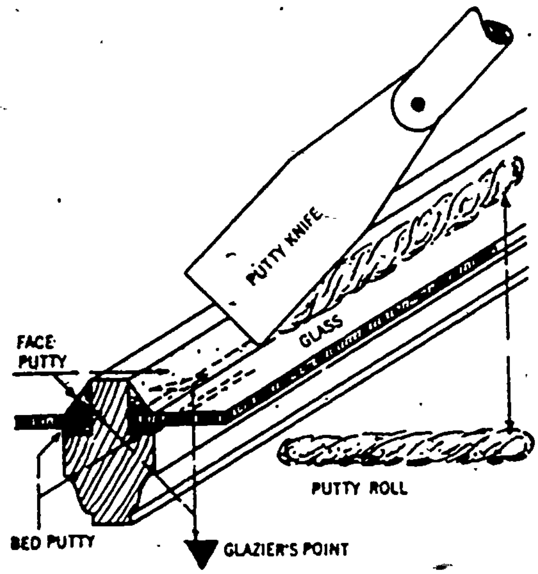



Figure 58. Setting glass with putty.

screens. Window and door frames may be purchased or made in the shop to fit. You will need a good knowledge of the procedures for installing and repairing screens often as they are deteriorated by weather elements and frequently become damaged by handling when removed, installed or stored.

6-79. *Screen materials.* Much of the screening found on Army buildings is made of comparatively short-lived steel or iron wire, either painted or galvanized. Continued use of such screen cloth is not recommended for other than planned short-time use of structures. Do not use steel or iron wire screening in tropical zones. The use of corrosion and weather resistant material, such as copper, bronze, aluminum, or plastic, is recommended for most future screening needs. Large diameter (0.015-inch) metallic wire will give longer service in tropical areas where excessive condensation and salt air are encountered. Bronze wire, Type C, is recommended for use in barracks, dining facilities, and similar buildings where rough usage may be expected. Commercial bronze, better known as Type B, is not recommended for use in tropical areas.

6-80. Woven screen cloth with strands of any of the following preferred materials are acceptable:

- Copper, Type A; Bronze, Type C; Aluminum, Type G.
- Iron or steel, Type D or H, galvanized, japanned or painted, may be used on buildings planned for limited use, except in tropical zones.
- Nylon.
- Plastic, Vinylidence Chloride.

6-81. Screen cloth recommended for tropical areas is the 16 x 16 mesh per inch made of 0.015-inch diameter strands, with opening size not greater than 0.0475 inch. Other screen material of 18 x 18 mesh with 0.011-inch strands is suitable for most locations.

6-82. *Repairing frames.* Screen doors and window screen frames are usually made of ¾ to 1⅛-inch thick western red cedar, preservative-treated ponderosa pine, northern white pine, Idaho white pine, sugar pine, or heart cypress. Wood frame screen doors and window screens should be removed in winter if insects are not a problem. They should be repaired at this time and stored in a dry place (off the ground or concrete) until needed. Repairs may consist of the following items:

- Replace damaged end rails, split stiles, etc.
- Replace loose hooks or hangers (hinges).
- Paint frame or patch screen.
- Replace screen.

6-83. When replacing rails or stiles of frames, select suitable material of proper dimensions. Fasten the frame members, using any of the joints illustrated in figure 60. Preferably, match the other joints of the frame. An application of paint before installation is advisable.

6-84. Use screen hinges on screens that are

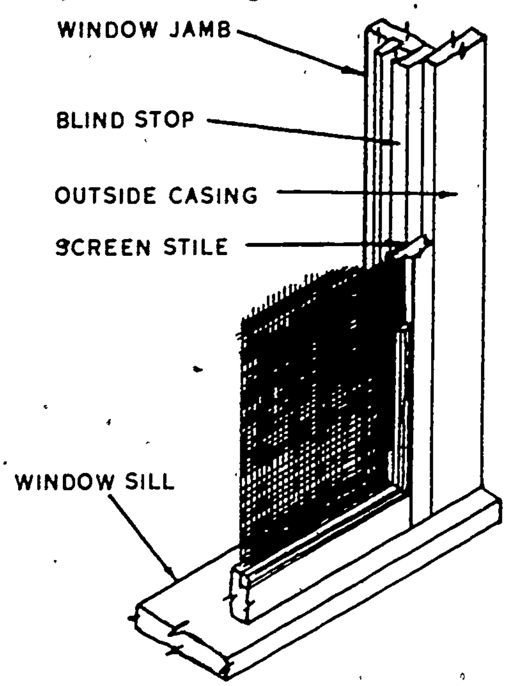



Figure 59. Window screen.

174

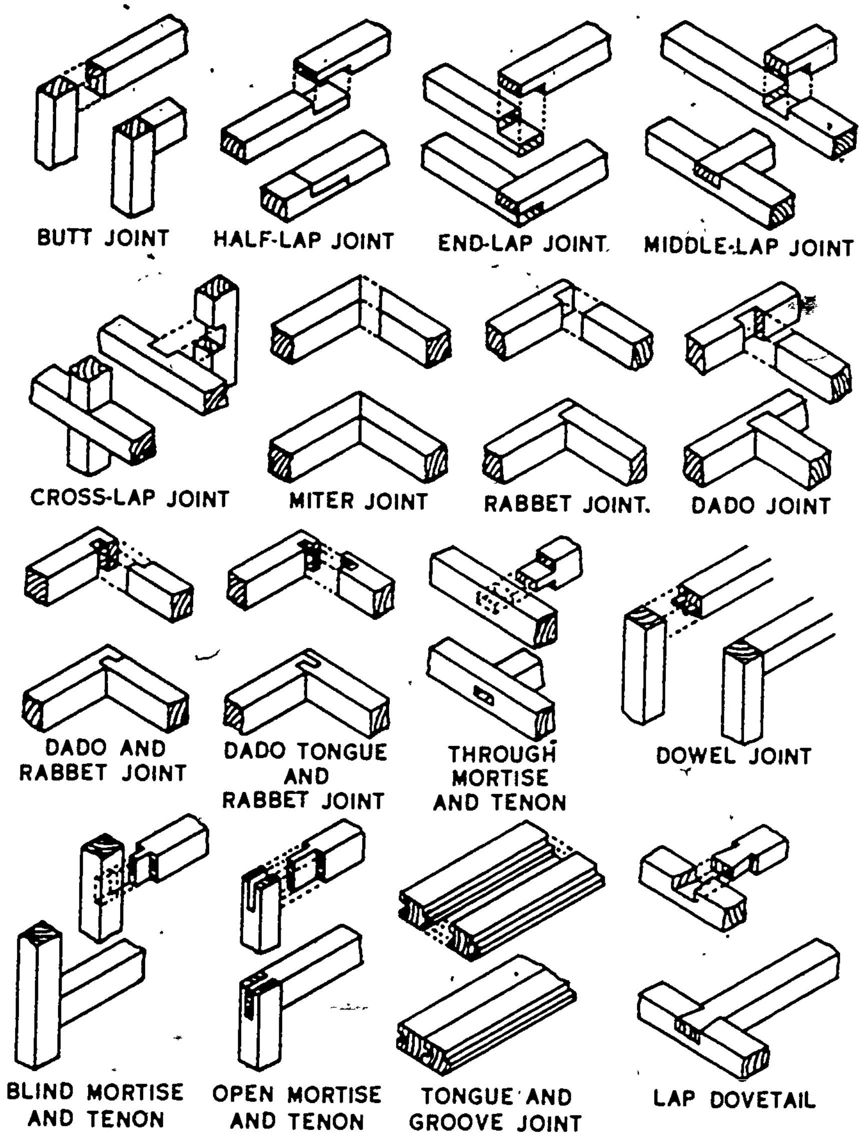



Figure 60. Joints for framing.

mounted flush with the outside casing. Mount the upper part of the hinge on the head casing and fasten the lower part over the joint made by the upper rail and end of a side stile, as shown in figure 61.

6-85. *Repairing Screens.* Tighten loose screens by removing a piece of molding and stretching the screen into place. You may repair small holes in the screen by patching, as shown in figure 62. Use like materials when patching—bronze on bronze, and aluminum on aluminum, etc.

6-86. Aluminum screens in aluminum sash require only a small amount of maintenance. Keep hangers and locking devices properly fastened and in working order.

6-87. Tension screens of aluminum alloys consist of the cloth, top and bottom bars (in place of rails), and attachment brackets. The selvage edges are pulled tight against outside blind stops; thus no guides or other framing is required. The sill bar is adjustable and can be arranged to provide continuous contact, even if the sill is not level. You may tighten the screen by adjusting the sill brackets.

6-88. Screen wire is applied to the frame in many different ways. One satisfactory method is to place the frame on a flat surface and unroll the screen wire on the frame. Fasten it in place with small staples placed approximately 3 inches apart. For best results, stretch the wire by hand while nailing it to the frame. Wire which

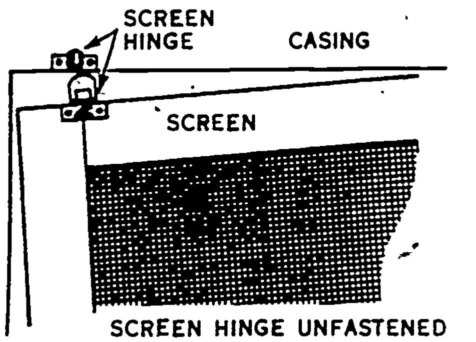



Figure 61. Window screen on screen hinges.

is stretched too tightly may bend the stiles and rails or tear the wire. Complete the installation of the screen wire by placing a small decorative molding over the edges of the wire, using 2d casing nails. Miter the corners of the molding for a neater appearance. You can use a linoleum knife to trim the screen wire flush with the outside of the molding, as shown in figure 63.

6-89. Especially where traffic is heavy, you may prevent sagging of screens on screen doors by installing pushbars and wire guards. Place pushbars of wood or metal about 45 inches above the floor, where the screen is most likely to be pushed when opening the doors. Wire guards cover the screen area between the lock and bottom rails. The guards may be prepared of ½-inch square mesh, 19-gage steel wire, or 1-inch diamond mesh woven from 16-gage steel wire. Prefabricated ornamental guards may be purchased. Set these guards against the screen and firmly secure them at all edges.

6-90. **Storm Doors and Sash.** In cold climates, the heat loss through doors and windows can be greatly reduced by installing storm doors and sash. Storm sash are prepared like window screens, except that the frames are rabbeted and glass is set in place of the screen. Storm doors are constructed similarly to storm sash. The doors may contain glass in the upper panel only or in the bottom panel as well.

6-91. Storm sash may be readily interchanged with screens, since they are usually hung from the same hinge bracket on the window casing and are locked with the same hook and eye on the inside bottom of the sash frame. The glass is secured to the frame with glazier points and putty, as shown in figure 64; however, a wooden molding may be used.

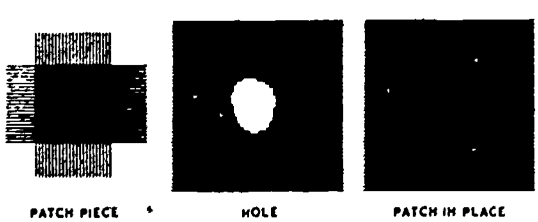



Figure 62. Patching small holes in window screens.

6-92. Some door and sash frames are constructed for combination use with screens or glass. In these frames, the screen and glass panels are rapidly changed by using simple fasteners. In many aluminum frames, the panels operate by sliding in a grooved mounting, making the panels "self-storing."

6-93. Maintenance tasks which you will be required to do on storm doors and sash are like those for screens and windows. Using the procedures which we previously discussed, you will be able to make the necessary repairs and replacements.

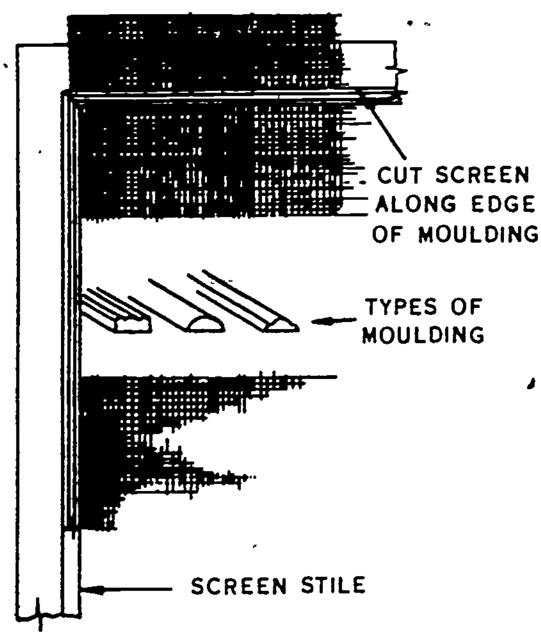



Figure 63. Trimming screen wire.

6-94. Just as it is necessary to provide for ventilation of the part of buildings which we occupy by installing doors and windows, it is highly desirable that the attic also be ventilated. One way of ventilating this area above the ceiling is to install louvers.

6-95. **Louvers.** Louvers are vents which are designed to prevent the entrance of rain or snow. They are usually installed in the gable of buildings near the roof, as shown in figure 65. Venting of the area where louvers are installed prevents condensation of moisture and allows escape of hot air to aid in cooling buildings.

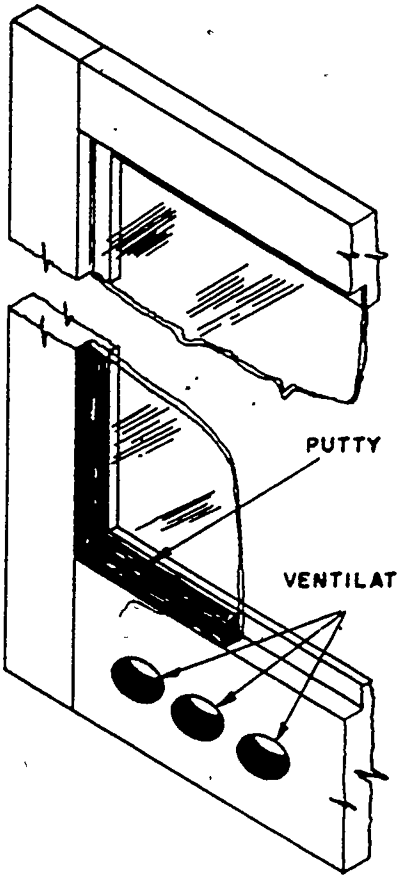



Figure 64. Storm sash.

6-96. You may construct louvers according to many designs or you may purchase them as prefabricated units. They may be made of either wood or metal, or a combination of both. Like windows, they are built within a frame. The frame holds horizontally mounted fins, vanes, or slats of metal or wood in a downward slanting position, from the inside to the outside. The slanting of the fins allows free circulation of air but prevents rain or snow from entering. The fins are usually nailed in position but may be adjustable for closing when desired. A screen is placed behind the fins to prevent entry of birds and insects.

6-97. Whether constructed in the shop or purchased, you will ordinarily install the louver as a unit. Installation procedures are the same as for windows. If maintenance is necessary, it usually will be better to remove the complete unit to so that repair of the frame, fins, or screen can be done more handily.

6-98. When all outside wall openings have been filled by installing doors, windows, and louvers, the exterior wall can be finished by covering it with siding and trim. Let's proceed with our discussion so that you can become proficient in finishing exterior walls.

## 7. Exterior Wall Finishing

7-1. Here we will actually discuss the "skin" of the building, which apparently is so important to its appearance and the satisfaction of those who see and use it. Although it is the thinnest part of the external wall, it certainly has important functions to perform besides those that can be seen. As our own skin holds and protects our bone framework and other vital functioning parts, so the exterior wall finish protects the rest of the wall from deterioration.

7-2. **Siding Materials.** Although there are many different types of materials used for exterior finishes, wood is ordinarily used, at least for the trim. In choosing wood for the exterior finish, you should consider several factors, such as decay resistance, paint-holding quality, and lumber grade. Always select the best lumber available for the exterior walls. Lumber that is warped or has an excessive amount of knots should not be used. Materials used on the exterior walls of a

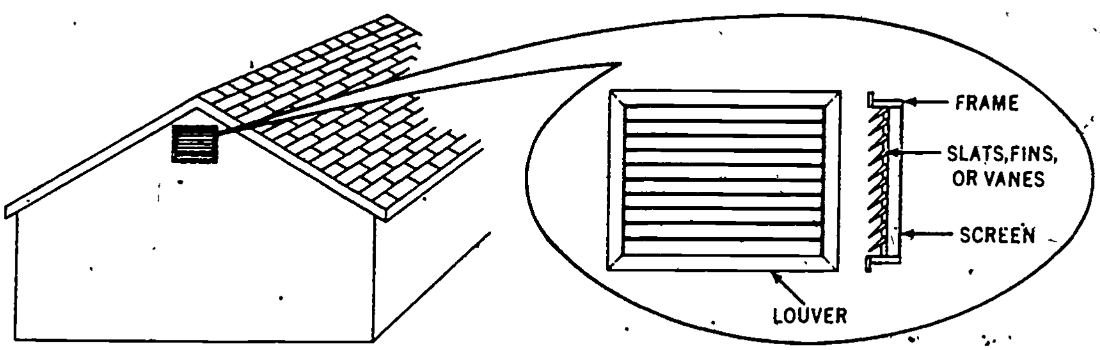



Figure 65. Louver installation.

building are building paper, plywood wall covering, wooden siding, asbestos shingles, wood shingles, metal siding, vinyl siding, and masonry finishes of stone, brick, or stucco.

7-3. *Building paper.* An important material which is almost indispensable in connection with outside finish is building paper. This paper serves two useful purposes: (1) waterproofing and (2) reducing the infiltration of air and dust. All such paper should be applied carefully around window and door frames. Take special care when applying building paper over wall sheathing to be sure that you make it waterproof and dustproof.

7-4. Overlap the paper edges so that the material will shed water, and do not use paper containing gaps or holes. Since this paper tears loose from ordinary nailheads or tackheads, nail through metal discs to secure the paper.

7-5. Building paper is a felt-type material and is asphalt or tar impregnated. It may sometimes be referred to as building felt, rather than paper. Different weights of building paper are available, but 15-pound paper (15-pounds per 100 square feet) is usually used under siding.

7-6. *Plywood wall covering.* Large panels of plywood are now available on the market for exterior use. In this plywood material, the various layers are bonded together with waterproof resin glues. The standard sizes for residential construction are 4′ x 8′ panels with varying thicknesses. In addition to increasing the rigidity of a building, plywood panels reduce the labor cost. These panels can be applied either horizontally or vertically on a stud wall frame.

7-7. *Wood siding.* Wood siding is the standard covering for wood frame buildings. It is milled in various patterns, as shown in figure 66. Since siding is exposed to the weather, the durability of the wood is an important factor to consider when selecting material for siding. Among the more durable woods for this purpose are cypress, cedar, and redwood. In addition to durability, these woods have good paint-holding qualities, which is another important consideration. A type of wall siding adapted to formal architecture is the novelty siding. Decorative effects may be obtained by scoring the siding vertically with a grooving tool. A rustic effect is produced by the log-cabin-type siding or by the V-rustic type. Drop siding makes a strong, tight wall which in itself is well insulated against wind and cold. It may use shiplap or tongue-and-groove joints. Bevel, or lap, siding is usually thinner and adds greatly to the softness and refinement of shadow lines. It may be rabbeted or simply lapped as clapboard.

7-8. When installing wood siding, you will nail it at the studs. Either box or casement nails may be used. Casement nails should be set and the holes filled with putty. This method is best where the paint to be used will not hold on metal surfaces without special priming. Drop siding and most types of novelty siding should be installed with 8d nails; bevel siding may be put on with the 6d size. The nails should be either rust-resistant (like galvanized nails) or rustproof (like aluminum nails) to prevent dark rust streaks from forming on the wood.

7-9. *Asbestos shingles (cement-asbestos).* One type of shingle which is frequently used in modification of Army buildings is the asbestos shingle. It is a hard, brittle shingle made of cement and asbestos. These siding shingles are fireproof and have replaced or covered the wood siding on many Army buildings. They are 5/32 inch thick, 12 inches wide, and 24 inches long, and are available in many colors.

7-10. Cement-asbestos shingles are installed with rustproof accessories. The nails are alumi-

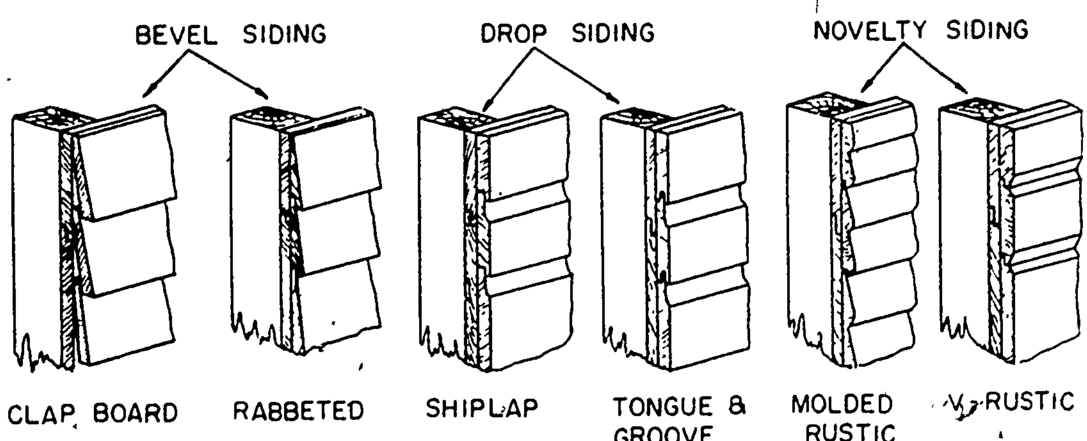



Figure 66. Types of siding.

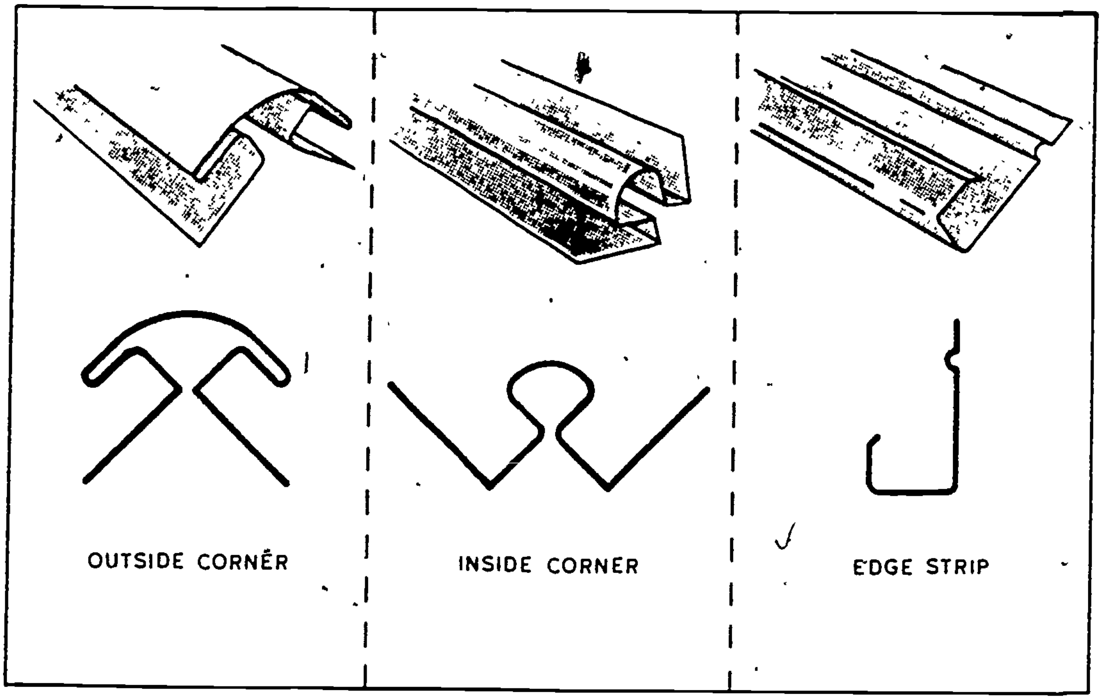



Figure 67. Shingle accessories.

num and have a flat head. Outside and inside corners and edge strips (shown in fig. 67) are installed over building paper before the shingles are placed. Felt strips are used under each joint, as shown in figure 68. All edges (around doors, windows, etc.) are calked to prevent water from getting behind the shingle. The color of the calking should blend with the color of the shingles. When the nails are driven too tight, they will cause the shingle to break. Whenever half shingles are required, they are cut with a shingle cutter (shown in fig. 69) designed for that purpose. Additional nail holes may be punched with the pin located on the handle. The nipper is used to chip out small portions to fit the shingle around obstructions.

7-11. Asbestos shingles are usually installed over ¾-inch sheathing because the random nailing does not occur on the studs. Some buildings have ¾-inch sheathing, paper, wood siding, more paper, and the asbestos shingle installed on the surface. When you are remodeling a building, it is more economical to leave the old siding (if it is not completely rotted or warped) and place the shingles over it.

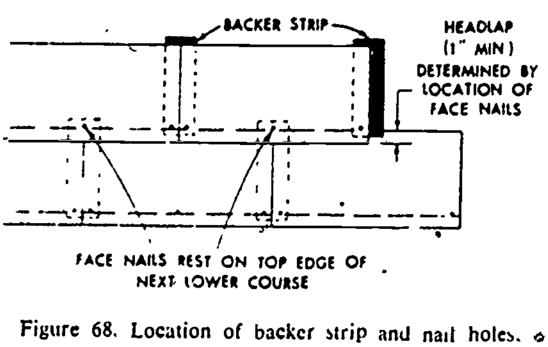



Figure 68. Location of backer strip and nail holes.

7-12. A common method for installing asbestos shingles over fiberboard or other nonlumber sheathing is illustrated in figure 70. When the sheathing will not hold nails, use channel molding to hold the shingles. Nail the molding to the studs.

7-13. *Wood shingles.* Wood shingles are installed with a doubled first course. The second layer is required to cover the joints in the first layer. Shingles used on exterior walls may be installed with more exposure to the weather (less overlap) than shingles on a roof, because the sun's heat does not reach them as directly and water runs off quickly. They do not have the same tendency to cup (curl up on the edges) while drying, because they dry more slowly than shingles on a roof. A quick change in moisture content will cause the shingles to rise at the edges or split.

7-14. Dry shingles are installed with a ¼-inch space between them to allow for expansion when they absorb water. The amount of exposure to the weather is different for each shingle length: 7½ inches exposed on 16-inch shingles,

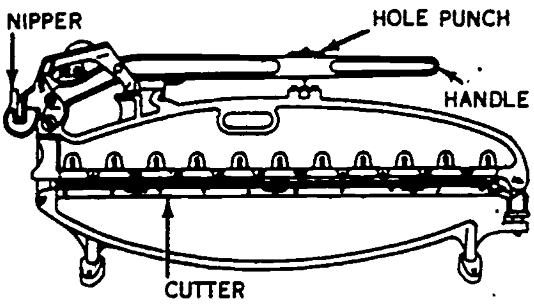



Figure 69. Shingle cutter.

8½ inches exposed on 18-inch shingles, and 11 inches exposed on 24-inch shingles. There must always be two layers of shingles to assure that water cannot enter through the joints.

7-15. Nails used to fasten shingles should be hot-dipped, zinc-coated shingle nails, or copper or aluminum for the best finish job. If a round nail is used, the type having a blunted 3-cornered tip is preferable, since the shingle is less likely to split. Each shingle is nailed near each edge. Shingles over 10 inches in width should have at least 3 nails in them. All nails should be driven flush and covered by the next course of shingles.

7-16. *Metal and vinyl (plastic or synthetic) siding*. There are presently several types of metal and synthetic plastic siding materials in use. Also, there are combination types where metal is used as the base with vinyl or other plastic coatings. Research will undoubtedly lead to the development of more of these materials in the future.

7-17. The metal siding materials usually are flat, corrugated, or V-crimped sheets. These sheets may be of galvanized iron, steel, or aluminum. Always install metal siding with nails made of the same or a compatible metal to prevent corrosive action from occurring. Galvanized lead-headed nails may be used with galvanized iron or steel siding, and aluminum nails with plastic or neoprene seals are commonly used with aluminum siding. These materials are used for covering sheds and other storage buildings where durability is more important than the architectural appearance.

7-18. Flat metal sheets may be purchased in almost any size, whereas corrugated and V-crimped sheets are usually 26 inches wide and in lengths of 6 to 12 feet. You may install these sheets horizontally, but they are more often placed vertically. Nail them on the top of the corrugations or crimps rather than in the valleys. The amount of nailing required will vary with the particular installation. Ordinarily a row of nails across the sheet at 2-foot intervals, with a nail on every fourth corrugation, will be adequate. The side lapping of V-crimped sheets is predetermined by its shape, whereas corrugated sheets should be lapped at least 1½ corrugations and nailed every 6 inches along the edge. The end laps, where necessary, should be approximately 4 to 6 inches.

7-19. Vinyl or other plastic materials are usually used for decorative purposes. Because of the ease of molding these materials during manufac-

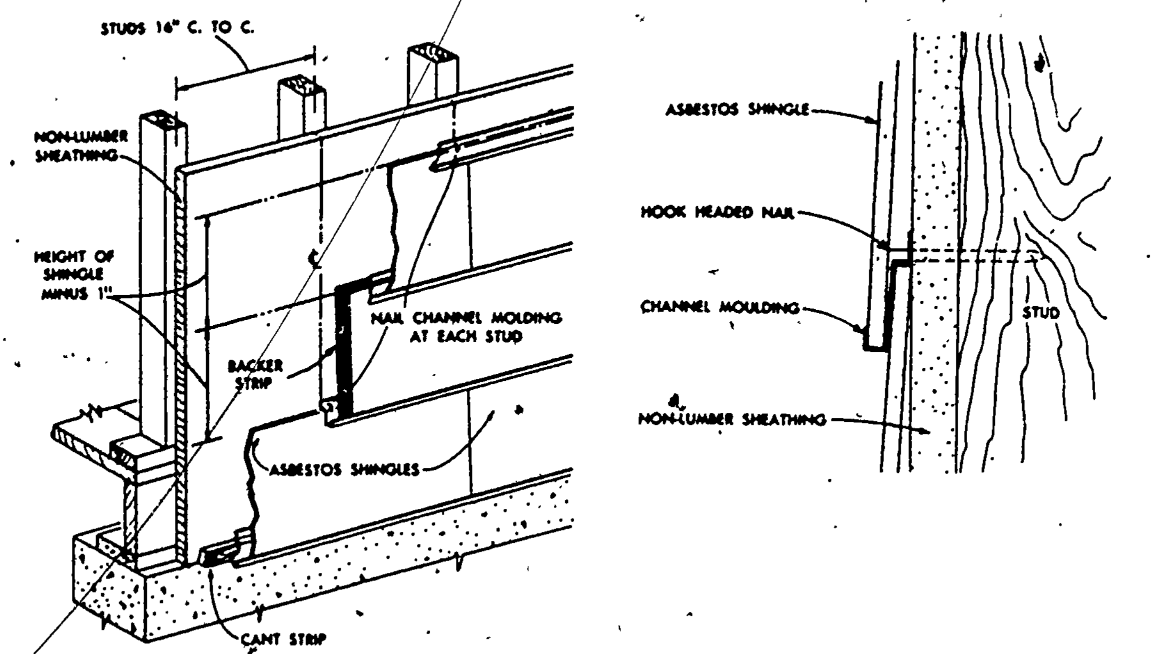



Figure 70. Use of channel molding.

180

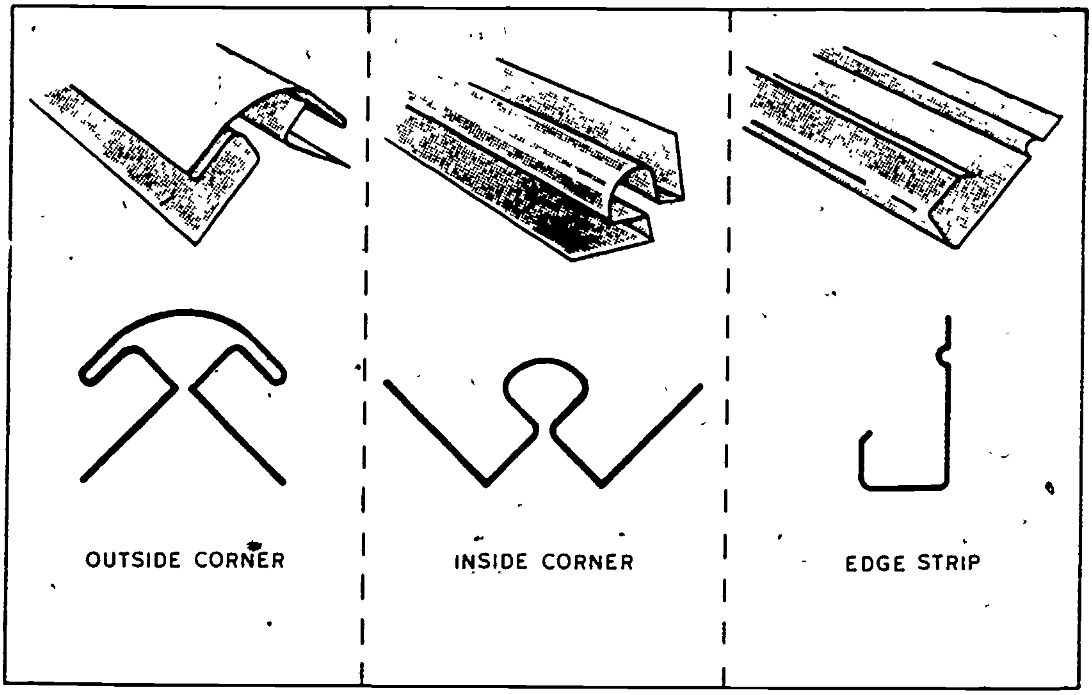



Figure 67. Shingle accessories.

num and have a flat head. Outside and inside corners and edge strips (shown in fig. 67) are installed over building paper before the shingles are placed. Felt strips are used under each joint, as shown in figure 68. All edges (around doors, windows, etc.) are calked to prevent water from getting behind the shingle. The color of the calking should blend with the color of the shingles. When the nails are driven too tight, they will cause the shingle to break. Whenever half shingles are required, they are cut with a shingle cutter (shown in fig. 69) designed for that purpose. Additional nail holes may be punched with the pin located on the handle. The nipper is used to chip out small portions to fit the shingle around obstructions.

7-11. Asbestos shingles are usually installed over ¾-inch sheathing because the random nailing does not occur on the studs. Some buildings have ¾-inch sheathing, paper, wood siding, more paper, and the asbestos shingle installed on the surface. When you are remodeling a building, it is more economical to leave the old siding (if it is not completely rotted or warped) and place the shingles over it.

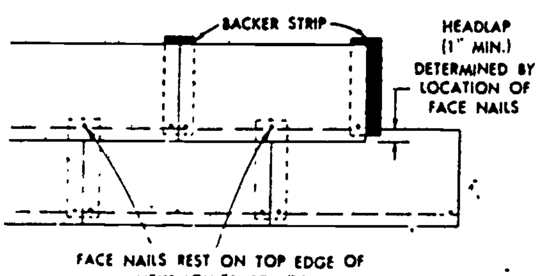



Figure 68. Location of backer strip and nail holes.

7-12. A common method for installing asbestos shingles over fiberboard or other nonlumber sheathing is illustrated in figure 70. When the sheathing will not hold nails, use channel molding to hold the shingles. Nail the molding to the studs.

7-13. *Wood shingles.* Wood shingles are installed with a doubled first course. The second layer is required to cover the joints in the first layer. Shingles used on exterior walls may be installed with more exposure to the weather (less overlap) than shingles on a roof, because the sun's heat does not reach them as directly and water runs off quickly. They do not have the same tendency to cup (curl up on the edges) while drying, because they dry more slowly than shingles on a roof. A quick change in moisture content will cause the shingles to rise at the edges or split.

7-14. Dry shingles are installed with a ¼-inch space between them to allow for expansion when they absorb water. The amount of exposure to the weather is different for each shingle length: 7½ inches exposed on 16-inch shingles,

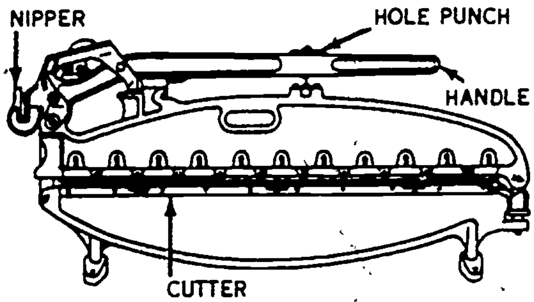



Figure 69. Shingle cutter.

8½ inches exposed on 18-inch shingles, and 11 inches exposed on 24-inch shingles. There must always be two layers of shingles to assure that water cannot enter through the joints.

7-15. Nails used to fasten shingles should be hot-dipped, zinc-coated shingle nails, or copper or aluminum for the best finish job. If a round nail is used, the type having a blunted 3-cornered tip is preferable, since the shingle is less likely to split. Each shingle is nailed near each edge. Shingles over 10 inches in width should have at least 3 nails in them. All nails should be driven flush and covered by the next course of shingles.

7-16. *Metal and vinyl (plastic or synthetic) siding*. There are presently several types of metal and synthetic plastic siding materials in use. Also, there are combination types where metal is used as the base with vinyl or other plastic coatings. Research will undoubtedly lead to the development of more of these materials in the future.

7-17. The metal siding materials usually are flat, corrugated, or V-crimped sheets. These sheets may be of galvanized iron, steel, or aluminum. Always install metal siding with nails made of the same or a compatible metal to prevent corrosive action from occurring. Galvanized lead-headed nails may be used with galvanized iron or steel siding, and aluminum nails with plastic or neoprene seals are commonly used with aluminum siding. These materials are used for covering sheds and other storage buildings where durability is more important than the architectural appearance.

7-18. Flat metal sheets may be purchased in almost any size, whereas corrugated and V-crimped sheets are usually 26 inches wide and in lengths of 6 to 12 feet. You may install these sheets horizontally, but they are more often placed vertically. Nail them on the top of the corrugations or crimps rather than in the valleys. The amount of nailing required will vary with the particular installation. Ordinarily a row of nails across the sheet at 2-foot intervals, with a nail on every fourth corrugation, will be adequate. The side lapping of V-crimped sheets is predetermined by its shape, whereas corrugated sheets should be lapped at least 1½ corrugations and nailed every 6 inches along the edge. The end laps, where necessary, should be approximately 4 to 6 inches.

7-19. Vinyl or other plastic materials are usually used for decorative purposes. Because of the ease of molding these materials during manufac-

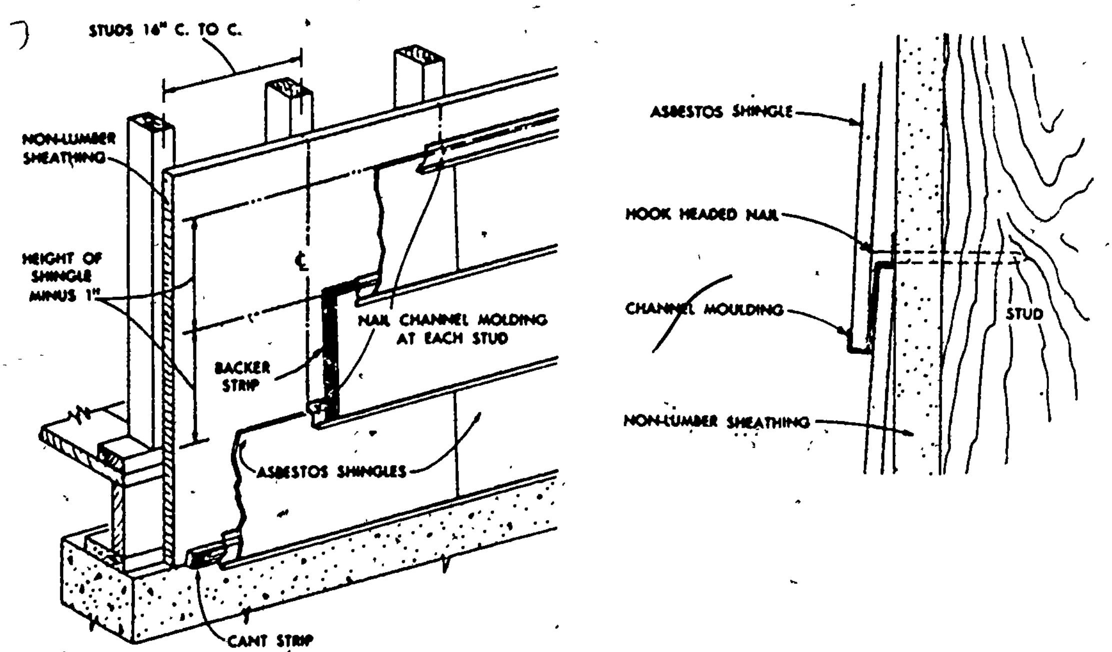



Figure 70. Use of channel molding.

ture, they may be made in a variety of shapes. A wide selection of colors is also available. Special nails are available, and you should select them to match the material. The amount of nailing required will vary with the shape of the material and the characteristics of the installation. However, the general methods used for fastening metal siding may often be used.

7-20. Precoated or combination metal and plastic siding is usually formed to resemble some type of wooden siding. Usually some type of channel molding is used to install this kind of siding so that nailing through the precoating material is avoided. In cases where new or special types of siding materials are being installed, consult the manufacturer for recommendations concerning methods and fastening devices.

7-21. It seems that any job or project always requires a "last minute touch"; that is, the "trimming" or the adding of something to make the job complete. This is also true in finishing an exterior wall. Boards are installed in several locations because they make the building look more complete. Let's discuss the location of external trim and the other purposes which it serves.

7-22. **External Trim.** Don't misunderstand. Installing the trim cannot be done during the last minute of exterior wall finishing. A considerable amount of time will be required to properly install the trim boards. They are not necessarily the last boards installed, either. They usually are placed on the sheathing before the siding is installed but can be nailed on or over the siding. Exterior trim includes door and window casings, water tables, corner boards and cornice.

7-23. When the trim is installed before the siding, the trim forms a border within which the siding is placed. The squared ends of the siding material are butted against the edges of the trim. If you carefully cut and install the siding, the joints will be easy to seal. If the trim is nailed over the siding, accurate cutting of the siding is unnecessary, since the joints are covered by the trim.

7-24. Exterior trim is usually of 1-inch finish lumber. The width may vary with the architectural design, but usually will be of 4-inch finish boards. Select good, straight boards which are free of knots for use as exterior trim.

7-25. *Door and window casings.* Usually these casing boards are installed with the door and window frames, as we have previously discussed. These boards are ordinarily 1 x 4's which are nailed to the door or window frames on one edge and to the trimmers and headers on the other edge. They assist in holding the door or window frames in place and cover the space between the frames and the trimmers and headers.

7-26. A drip cap is usually installed as a part of the casing above doors and windows to prevent entry of moisture behind the casing. In other cases, a flashing is formed of copper or galvanized sheet metal to extend under the siding and over the upper casing.

7-27. *Water table.* The lowest part of the outside finish of a wooden structure that meets the eye is the water table. It consists of two parts: a baseboard, which is installed where the foundation wall stops and the framework begins, and a drip cap, which is installed above the baseboard.

7-28. The purpose of the water table is to protect the foundation sills by deflecting rainwater away from the sills. Without a water table, water running down the walls would seep in between the foundation and sills, thus damaging the sills. Therefore, the water table is important and must be constructed with great care. Two different methods of constructing the water table are shown in figure 71. Since the outside wall covering begins at the water table, the water table must be constructed first.

7-29. *Corner boards.* At the corners of the building, the wall covering, either shingles or siding, can be treated in one of several ways. The siding or shingles can be beveled and fitted together. The shingles can be lapped alternately, the siding can be butted and covered with metal caps, or corner boards (shown in fig. 72) can be installed.

7-30. You should tack a strip of building paper over the corner before placing the corner board in position for nailing, as illustrated in figure 73. To avoid a rounding at the corner, you should fold the paper lengthwise and crease it to fit the corner of the building.

7-31. *Cornice.* Just as the water table frames the bottom of a wall and the corner boards frame the sides, the cornice boards complete the trimming by framing the top of the wall. Cornice boards are usually 6 inches or more wide and are nailed to the wall just below the eaves of the roof, as shown in figure 74.

7-32. At this point in our discussion of exterior framing, you should have a good understanding of the principles and methods used for building the wooden frame, installing doors and windows, and putting on the external wall finish. One more task should be done after application of the primer coat of paint. All joints between the siding and trim should be made airtight and moistureproof by filling them with calking compound.

7-33. **Calking.** Even when the joints between the window and door casings and sills are made carefully and accurately, moisture still may enter.



182

82

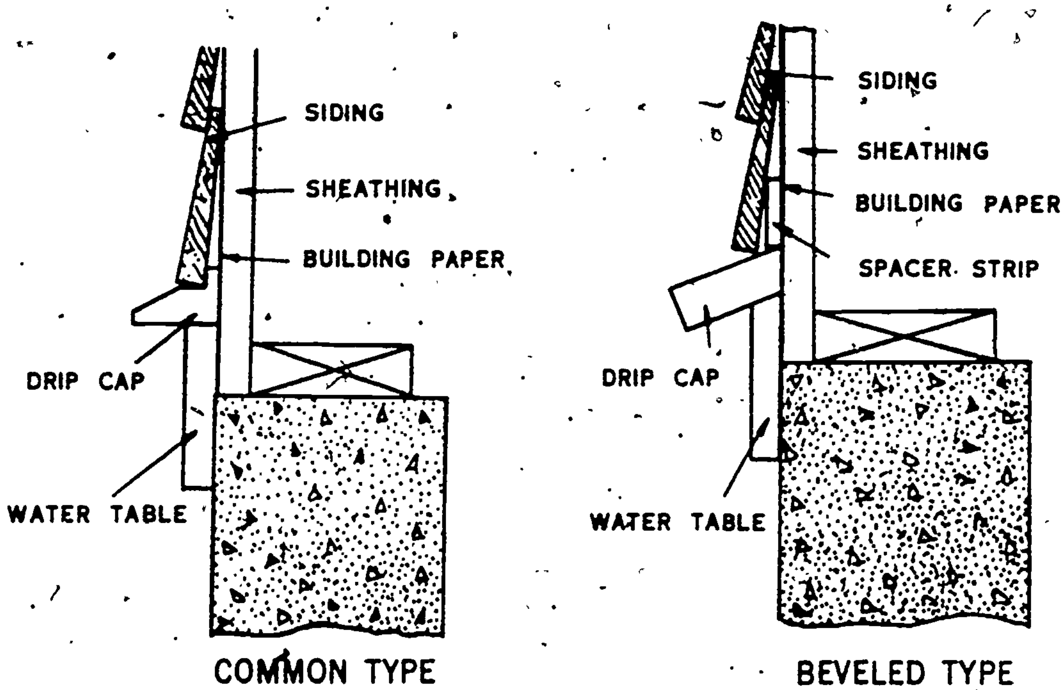



Figure 71. Water table construction.

If the back (unpainted) sides of these external finishing boards become wet, the boards will rot, since they dry very slowly. Calking compound, a soft, adhesive filler material, is applied to fill and seal these joints. The joints between the siding and corner boards are often calked, too.

7-34. *Calking compounds.* A suitable calking compound is composed of pigments (or fillers), a liquid, and mineral fibers. The consistency of the compound depends upon the amount of each part in the mixture. There are two grades of commercially recognized calking compounds: grades 1 and 2. Grade 1 is of a soft consistency suitable for application with a calking gun. Grade 2 has the consistency of glazing putty and is applied with a knife. Calking compounds are available in at least twenty shades and colors, including black, white, and aluminum. Gun application of grade 1 is recommended for general use, since it is easy to apply, is economical, and takes about one-third the time required for knife application. You may use a knife for application where a neat finished appearance for some conspicuous location is desired. Both grades of calking compound are available in bulk containers, and grade 1 is also furnished in tubes.

7-35. *Calking guns.* Most calking guns are hand operated. The standard hand-operated gun, as illustrated in figure 75, consists of a compound reservoir, nozzle, handle, piston, ratchet rod, and trigger mechanism. Gun nozzles are available in many sizes and shapes. Tip openings are furnished for use in level or angled application of the compound. You will save time if you select the proper nozzle for the particular job. When applying the calking compound, place the nozzle tip at, or preferably insert it into, the joint to be filled. Apply the calking compound by a coordinated action of pumping the compound with the trigger while moving the tip of the nozzle along the joint.

7-36. Wooden structures which are given a coat of paint as needed will usually last for many years. There are buildings in the world that are several hundred years old to attest to this fact. However, it is not difficult to find examples of other buildings which, because of neglect, have deteriorated into dilapidated shacks within a very short time. Perform good, timely maintenance to the exterior finish of buildings and you will preserve them for the use of future generations.

7-37. **Maintenance of Exterior Finish.** The most common failure of wood and wood products, exterior siding, and trim is caused by moisture. Of course, some deterioration can be expected from ordinary wear and tear. Sadly enough, there is also breakage which results from misuse and abuse. Whether weathering, normal wear, or other factors necessitate repair, replacement, or refinishing of an exterior wall, you must give consideration to matching or duplicating the material of the existing finish.

7-38. Most of the siding you will be replacing

184

ture, they may be made in a variety of shapes. A wide selection of colors is also available. Special nails are available, and you should select them to match the material. The amount of nailing required will vary with the shape of the material and the characteristics of the installation. However, the general methods used for fastening metal siding may often be used.

7-20. Precoated or combination metal and plastic siding is usually formed to resemble some type of wooden siding. Usually some type of channel molding is used to install this kind of siding so that nailing through the precoating material is avoided. In cases where new or special types of siding materials are being installed, consult the manufacturer for recommendations concerning methods and fastening devices.

7-21. It seems that any job or project always requires a "last minute touch"; that is, the "trimming" or the adding of something to make the job complete. This is also true in finishing an exterior wall. Boards are installed in several locations because they make the building look more complete. Let's discuss the location of external trim and the other purposes which it serves.

7-22. **External Trim.** Don't misunderstand. Installing the trim cannot be done during the last minute of exterior wall finishing. A considerable amount of time will be required to properly install the trim boards. They are not necessarily the last boards installed, either. They usually are placed on the sheathing before the siding is installed but can be nailed on or over the siding. Exterior trim includes door and window casings, water tables, corner boards and cornice.

7-23. When the trim is installed before the siding, the trim forms a border within which the siding is placed. The squared ends of the siding material are butted against the edges of the trim. If you carefully cut and install the siding, the joints will be easy to seal. If the trim is nailed over the siding, accurate cutting of the siding is unnecessary, since the joints are covered by the trim.

7-24. Exterior trim is usually of 1-inch finish lumber. The width may vary with the architectural design, but usually will be of 4-inch finish boards. Select good, straight boards which are free of knots for use as exterior trim.

7-25. *Door and window casings.* Usually these casing boards are installed with the door and window frames, as we have previously discussed. These boards are ordinarily 1 x 4's which are nailed to the door or window frames on one edge and to the trimmers and headers on the other edge. They assist in holding the door or window frames in place and cover the space between the frames and the trimmers and headers.

7-26. A drip cap is usually installed as a part of the casing above doors and windows to prevent entry of moisture behind the casing. In other cases, a flashing is formed of copper or galvanized sheet metal to extend under the siding and over the upper casing.

7-27. *Water table.* The lowest part of the outside finish of a wooden structure that meets the eye is the water table. It consists of two parts: a baseboard, which is installed where the foundation wall stops and the framework begins, and a drip cap, which is installed above the baseboard.

7-28. The purpose of the water table is to protect the foundation sills by deflecting rainwater away from the sills. Without a water table, water running down the walls would seep in between the foundation and sills, thus damaging the sills. Therefore, the water table is important and must be constructed with great care. Two different methods of constructing the water table are shown in figure 71. Since the outside wall coving begins at the water table, the water table must be constructed first.

7-29. *Corner boards.* At the corners of the building, the wall covering, either shingles or siding, can be treated in one of several ways. The siding or shingles can be beveled and fitted together. The shingles can be lapped alternately, the siding can be butted and covered with metal caps, or corner boards (shown in fig. 72) can be installed.

7-30. You should tack a strip of building paper over the corner before placing the corner board in position for nailing, as illustrated in figure 73. To avoid a rounding at the corner, you should fold the paper lengthwise and crease it to fit the corner of the building.

7-31. *Cornice.* Just as the water table frames the bottom of a wall and the corner boards frame the sides, the cornice boards complete the trimming by framing the top of the wall. Cornice boards are usually 6 inches or more wide and are nailed to the wall just below the eaves of the roof, as shown in figure 74.

7-32. At this point in our discussion of exterior framing, you should have a good understanding of the principles and methods used for building the wooden frame, installing doors and windows, and putting on the external wall finish. One more task should be done after application of the primer coat of paint. All joints between the siding and trim should be made airtight and moistureproof by filling them with calking compound.

7-33. **Calking.** Even when the joints between the window and door casings and sills are made carefully and accurately, moisture still may enter.

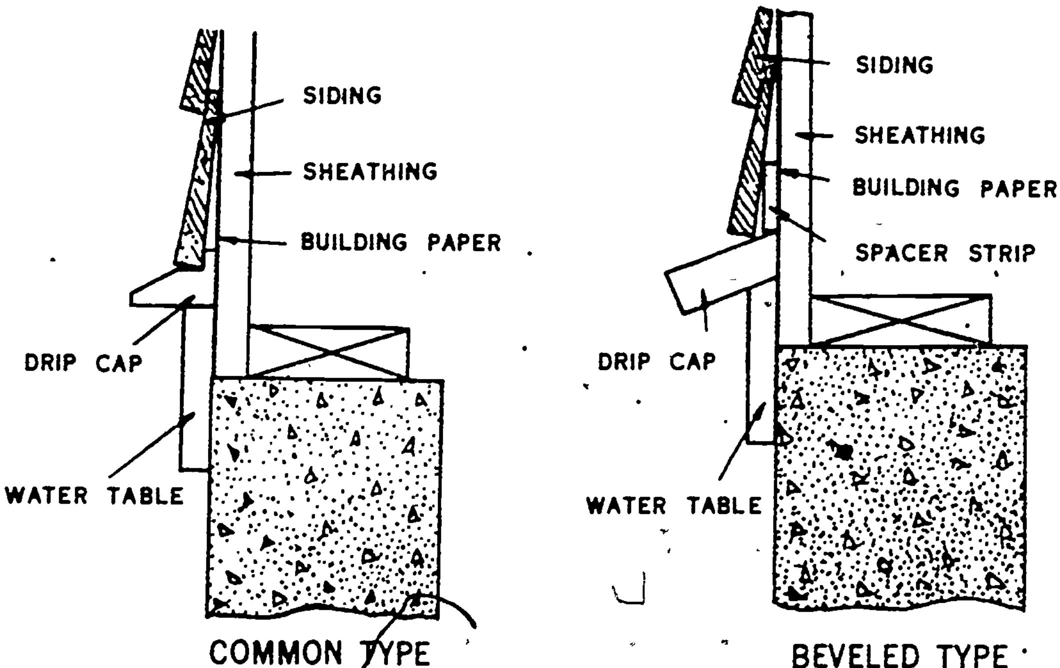



Figure 71. Water table construction

If the back (unpainted) sides of these external finishing boards become wet, the boards will rot, since they dry very slowly. Calking compound, a soft, adhesive filler material, is applied to fill and seal these joints. The joints between the siding and corner boards are often calked, too.

7-34. *Calking compounds*. A suitable calking compound is composed of pigments (or fillers), a liquid, and mineral fibers. The consistency of the compound depends upon the amount of each part in the mixture. There are two grades of commercially recognized calking compounds: grades 1 and 2. Grade 1 is of a soft consistency suitable for application with a calking gun. Grade 2 has the consistency of glazing putty and is applied with a knife. Calking compounds are available in at least twenty shades and colors, including black, white, and aluminum. Gun application of grade 1 is recommended for general use, since it is easy to apply, is economical, and takes about one-third the time required for knife application. You may use a knife for application where a neat finished appearance for some conspicuous location is desired. Both grades of calking compound are available in bulk containers, and grade 1 is also furnished in tubes.

7-35. *Calking guns*. Most calking guns are hand operated. The standard hand-operated gun, as illustrated in figure 75, consists of a compound reservoir, nozzle, handle, piston, ratchet rod, and trigger mechanism. Gun nozzles are available in many sizes and shapes. Tip openings are furnished for use in level or angled application of the compound. You will save time if you select the proper nozzle for the particular job. When applying the calking compound, place the nozzle tip at, or preferably insert it into, the joint to be filled. Apply the calking compound by a coordinated action of pumping the compound with the trigger while moving the tip of the nozzle along the joint.

7-36. Wooden structures which are given a coat of paint as needed will usually last for many years. There are buildings in the world that are several hundred years old to attest to this fact. However, it is not difficult to find examples of other buildings which, because of neglect, have deteriorated into dilapidated shacks within a very short time. Perform good, timely maintenance to the exterior finish of buildings and you will preserve them for the use of future generations.

7-37. **Maintenance of Exterior Finish.** The most common failure of wood and wood products, exterior siding, and trim is caused by moisture. Of course, some deterioration can be expected from ordinary wear and tear. Sadly enough, there is also breakage which results from misuse and abuse. Whether weathering, normal wear, or other factors necessitate repair, replacement, or refinishing of an exterior wall, you must give consideration to matching or duplicating the material of the existing finish.

7-38. Most of the siding you will be replacing

186

has a rabbeted or lap joint, or a tongue-and-groove joint. Boards that have a lap joint may be easily removed by cutting the nails or driving the small nailheads completely through the board. Boards with tongue-and-groove joints may be broken lengthwise and removed in sections to prevent damage to adjoining boards. Remove the back side of the groove on the new board so that it will slip into place just like a shiplap joint. When only a part of a board is to be replaced, you will need to cut the board with a wood chisel so that the joint will be on the center of a stud. This will provide a nailing surface for the ends of the old and new boards.

7-39. You must work carefully in replacing an asbestos shingle to prevent damaging adjoining shingles. The best method is to cut the nails before attempting to remove the shingle. If the nails have worked loose and the head can be grasped with the claws of a hammer, you can pull them. However, you cannot pry against the good shingles with the hammer. Use a strip of wood as a cushion under the hammer to prevent breaking the good shingles. The new shingle must have nail holes punched in it so that it can be face nailed along the upper edge (close to the shingle lapping it from above). You may also need to loosen the lower nails in the shingles above the one you removed so that the new shingle will slide into place without damaging the building paper. Fasten all nails after you nail the new one in place. When replacing one shingle or a group of shingles in the same course, it is necessary to have some exposed nails. These exposed nails must be rustproof to prevent rust stains from appearing on the shingles.

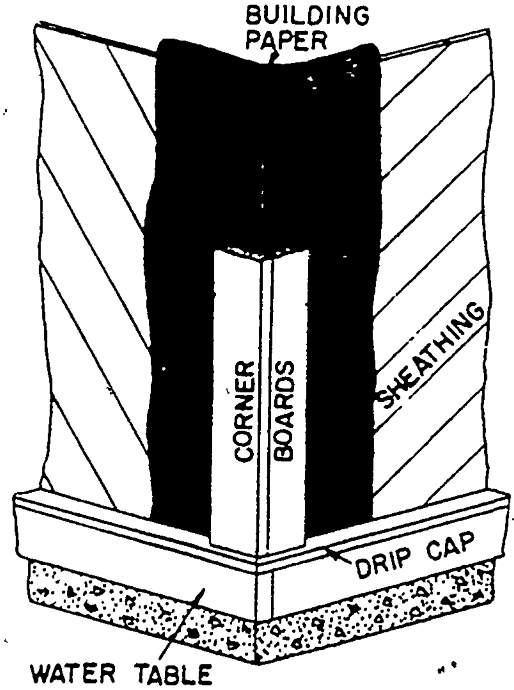



Figure 73. Corner board installation.

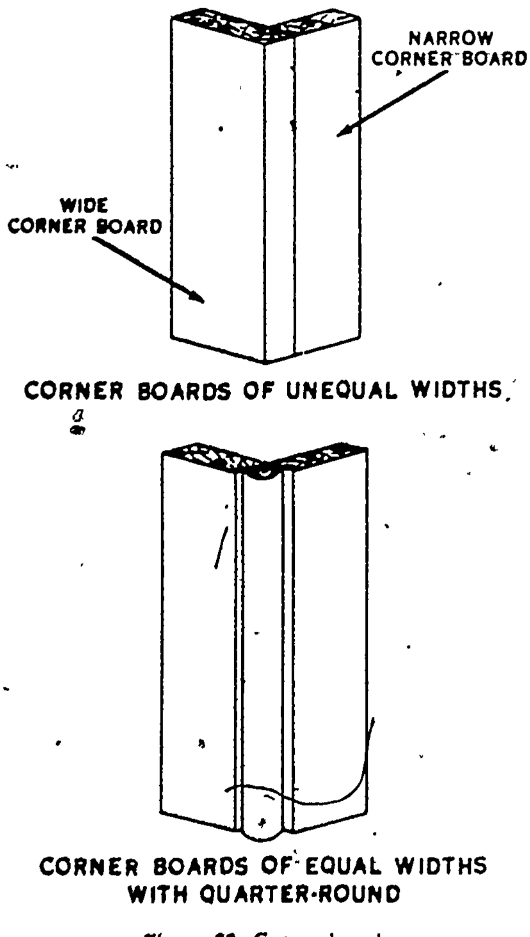



Figure 72. Corner boards.

7-40. After repairs are made, recalking is necessary. Also, periodic inspection of calked joints will reveal a need for removing cracked and curled calking compound and for refilling the joints. The success of a calking job is, to a large extent, dependent upon proper preparation of the surfaces to which the compound will be applied. The old calking material must be thoroughly removed before applying the new material.

7-41. To complete our study of the external portions of buildings, let's now discuss the external entranceways which are located at the outside doors. These porches may be quite simple in construction but can be rather complex. Because they are used so extensively, you should have a good knowledge of their construction features.



88

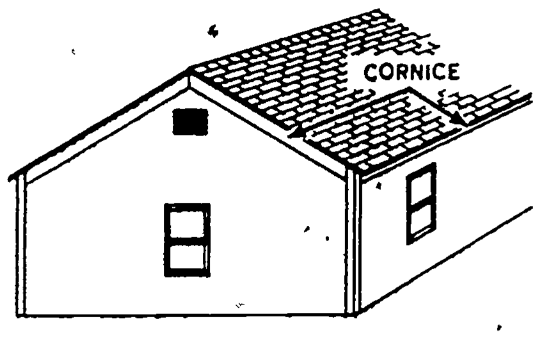



Figure 74. Cornice boards.

## 8. Porches

8-1. The purpose which a porch serves is determined by the way it will be used. In some instances, only a step or two is needed to assist in movement from ground level into the doorway at an elevated position. In other cases, a platform of some size at the doorway is desirable. Protection of the doorway from rain and snow is afforded by addition of a roof, whereas further protection from wind and insects may be given by inclosures of wood, glass, or screen.

8-2. Porches can be made of wood or concrete. Concrete porches have footings, walls, and floors which are reinforced with steel rods. A smooth layer of concrete is used to finish the walls, steps, and floors. Since you will build the forms for concrete, you should have a general understanding of the concrete work involved. Both wooden and concrete porches have a foundation, sills, joists, flooring, roof rafters, sheathing, and roofing.

8-3. **Foundations and Piers.** Since all porches do not rest directly on the ground, they must be supported by posts or piers. Unless they are large and two or more stories high, they do not weigh enough by themselves to require massive foundations. Pier foundations are generally sufficient to carry the load. Small porches or stoops, which are 4 to 6 feet square, require footings of not more than 12 inches square and 6 inches thick. The general type of front or side porch usually requires concrete footings 18 inches square and 8 inches thick. Such footings should not be spaced more than 10 feet apart. Large porches in which the piers exceed the 10-foot spacing, especially if they are inclosed, should have concrete footings 24 inches square and 12 inches thick. For porches that are less than 2 or 3 feet above the ground, it is better to carry the masonry piers or foundation work of the porch to the underside of the porch framing. This adds to the appearance and the ability to withstand shock and wear.

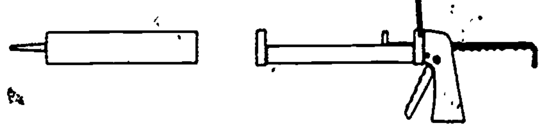


Figure 75. Calking gun.

8-4. Openings should be provided to permit air to circulate under the porch.

8-5. It is more economical to use a wood post extending from the foundation to the underside of the porch framing for porches more than 2 or 3 feet above the ground. When you use wood, it should not be less than 5″ x 5″ square, and its supporting masonry work should be at least 6 inches above the ground. The end of the wooden post which comes in contact with the masonry should be protected from moisture. The woods best suited for supports or piers are redwood, cypress, and cedar. Figure 76 illustrates three types of porch piers.

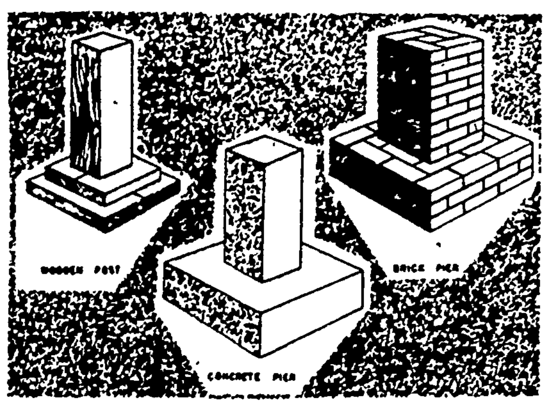



Figure 76. Porch piers.

8-6. **Porch Joists.** Floor joists and porch joists are similar in function. However, there is a need for greater weather-resistant qualities for porch joists; this is especially true for the outside joists. To provide adequate drainage, a porch floor should slope ¼ inch per foot away from the wall of the building. Since there is no subfloor, this requires that the flooring run in the direction of the slope—or at right angles to the wall. To provide a bearing for the joists, a series of girders is run from the wall to the piers. The joists are placed at right angles to these griders and rest on top of them, or they can be cut to fit between them. Figure 77 illustrates porch joist and girder construction. Porch joists are usually spaced 16 to 30 inches apart, depending on the floor thickness and the type of wood used. You should use moisture-resistant wood, free from decay, and the wood should be treated with creosote or a standard preservative such as zinc chloride. Framing methods for porch joists are the same as for

188

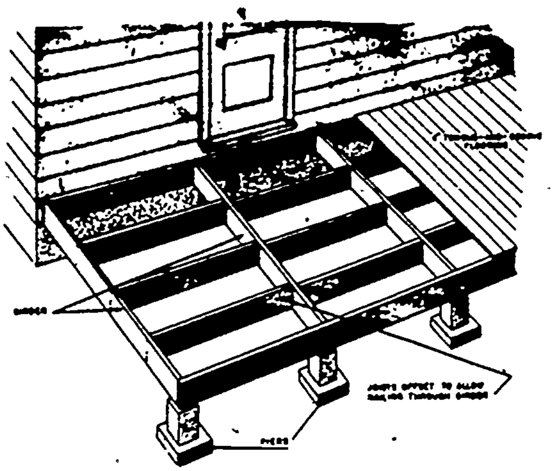


Figure 77. Porch joists.

floor joists except for providing adequate drainage.

8-7. **Porch Girders.** Girders for porches are required as part of porch framing to carry the porch joists, just as main girders carry the floor joists of a building. Because porch girders carry only the weight of the porch floor and joists (there are no bearing partitions), there is no need to consider any load other than 40 pounds per square foot live load plus 10 pounds as a good average for the dead load. Redwood, cypress, and cedar are suitable woods for porch girders in any of the common grades. If any of the less decay-resistant woods are used, they should be treated with creosote or zinc chloride.

8-8. The length of porch girders should be sufficient to give at least a 3-inch bearing on both walls and piers. Porch joists may rest on top of the girders or be carried on ledger boards, which should be securely nailed.

8-9. **Porch Flooring.** A porch floor covers the joists and forms the wearing surface. It should be installed to resist the effects of moisture and rainwater. You should use matched flooring strips, with the joints well sealed with white lead. With the joints protected, the slope of the floor will permit water to drain off rapidly. In areas where heavy snows are frequent, the flooring strips are sometimes laid with a space of ⅛ or ¼ inch between each strip to allow the melting snow to drain off more rapidly. Any softwood species ordinarily used for flooring is suitable for porch floors. If flat grain (or plain sawed) flooring is used, it should be kept well painted. This will reduce splintering caused by hard wear on flat grain or plain-sawed flooring.

8-10. **Porch Posts or Columns.** A porch post or column is a vertical member that rests on the porch floor—or in some cases upon the pier itself. Its purpose is to support the roof over the porch, and if it is decorative, it can add dignity and beauty to the exterior of a building.

8-11. The placement of the columns or posts is more a matter of good taste and architecture than of any strength requirement; therefore, posts or columns are usually made much larger than actually needed to support the load of the roof. A 4" x 4" post or even a 2" x 4" post, especially if braced sideways by a porch rail, may be strong enough. However, this type of arrangement will look flimsy and is not pleasing to the eye. For this reason, porch posts or columns are often built up to give the impression of solidity. Figure 78 illustrates built-up posts or columns.

8-12. Any commercial species of wood is suitable for porch columns or posts, provided it is seasoned and properly painted. Built-up columns, particularly round, are ordinarily purchased in finished shape from the mill; nevertheless, they should be selected for weather-resisting qualities, especially the material for the base. Simple built-up columns can be made up on the job site out of dressed lumber. The base of a post or column should be securely nailed to the porch so that it won't move. The bottom members should be carefully installed to permit water to run off freely and quickly, avoiding the tendency for decay.

8-13. **Porch Roofs and Ceilings.** Generally speaking, there are three main types of porch roofs: shed, gable, and hip, as shown in figure 79. The construction features and principles for porch roof framing are the same as for the rest of the roof. A discussion of the procedures for building the roof is presented in Chapter 3 of this volume. If a ceiling is installed, it will usually be of plywood or some type of tongue-and-groove boards. Installation of the ceiling will be

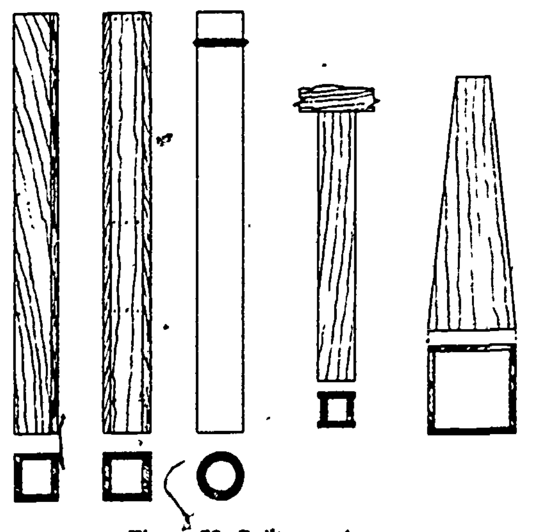


Figure 78. Built-up columns.



183

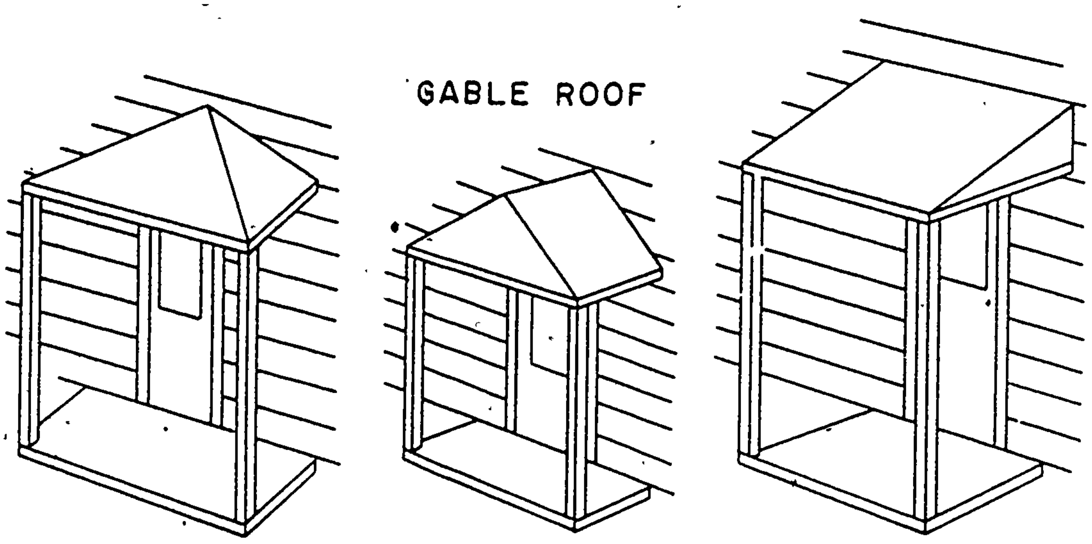



Figure 79. Porch roofs.

done in the same way that interior finish is applied to the ceiling joists. These procedures are further explained in Chapter 4.

8-14. **Porch Steps.** The approach to a building is important and, as far as carpentry is concerned, the steps or flight of stairs at the door or porch should be given careful consideration. This can be accomplished by answering these questions: Is it practical? Is it convenient? Is it substantial and does it harmonize with the main part of the building? Although outside steps involve the same principles as stairsteps, you will find different considerations, also. The procedures for cutting stringers and the details of stairway construction are discussed in Chapter 4, but we will discuss the peculiar aspects of outside steps at this time.

8-15. Outside steps are exposed to the weather and in many cases rest on the ground. Because of their exposed location, stair carriages and all other materials used should be selected with reference to resistance to decay and insect attack.

8-16. The principal consideration in placing and erecting stair carriages is that some protection be afforded to avoid contact with the ground. The bottoms should rest on some sort of concrete or stone foundation. It is good practice to prime paint the surfaces of the carriages to protect them from moisture, especially at the back where there is an opening between the tread and the riser. It is also desirable to cut the treads so that a slope of ¼ inch is obtained. This allows water to run off freely and is common practice for concrete, brick, or wooden steps. Except under unusual circumstances, the rise per step should not be more than 8 inches. There are times when 5½- and 6-inch risers are used, but from 6½ to 7 inches makes the most comfortable step to travel. There is no need for risers to be more than 1 inch thick, but they should be cut in over the tread to prevent water from working through the joints to the carriage below.

8-17. Although not a common practice, it is practical to plow furrows on the underside of treads at intervals of 3 or 4 inches and about ¼ inch deep. This will help prevent warping and will allow the tread to lie flat when securely nailed to the carriage. Material 1¼ inches in thickness is desirable for treads. If material thinner than this is used, it will be subject to warping and will not withstand heavy use. Treads should project 1 to 1½ inches beyond the face of the risers to provide a pleasing finish, especially if the treads are narrow.

8-18. You may also be required to build forms for concrete steps. Figure 80 illustrates one method for construction of stair forms for stairway widths up to 3 feet. The sloping wooden platform that makes up the form for the underside of the steps should be made of 1-inch tongue-and-groove sheathing. This panel should extend about 12 inches beyond each side of the stairs to provide a support for the stringer bracing blocks. The back of the sloping panel should be shored up with 4 x 4's as shown. The 2-inch cleats are spaced on 4-foot centers. The 4 x 4 post should rest on wedges to make it possible to remove the post without any difficulty. The side stringers are made of 2 x 12 lumber cut as required by the tread and riser dimensions. The piece forming the riser should also be 2-inch-thick material, beveled as shown.

8-19. **Porch Inclosures.** Inclosing of porches with screen wire is a common practice. In some cases, framed glass is used for a large portion of the inclosing walls. Where cold winds prevail, wood or partial wood inclosures are often used.

8-20. Inclosing a porch with wood is similar to building an external frame wall, except that the strength requirements are less. The spacing of frame members is greater, and sheathing is not required. The knowledge which you have gained in framing external walls should be sufficient to enable you to build these inclosures.

8-21. Likewise, to frame an inclosure for glass panels and to be able to install the panels or sash, recall the methods and procedures which we discussed concerning the rough framing for windows and their installation.

8-22. Porch screens may be made in the shop or at the job site. You may find places where the area must be framed with studs and block bridging to form a fastening surface for the screen. The screen is stapled to the frame, and ¼- x 1⅜-inch batten strips are fastened over the screen to help hold it securely to the frame.

8-23. Another large framing job consists of cutting the screen frame in the shop and assembling it at the job site. It is difficult to move large screens without breaking the joints or damaging the screen, and you may find it necessary to assemble them in the vicinity where they are to be used. Framing is usually made with simple joints, similar to those used in making window screens. You may be able to divide a screen, say 18 feet long, into 6-foot sections and build them in the shop. Where two screen frames butt together, you will need to either make tight joints or cover the joint with a batten, or both.

8-24. Placing the screen on the frame is an easy task if you get it started straight. The wire is woven with wires placed perpendicular to each other forming small squares. If you start fastening the screen at one end by alining one of these rows with the end of the frame, perpendicular rows should parallel the edges of the frame when the wire is stretched. Pull the screen tight after the end is secured with staples or tacks. Use a small awl (tool similar to a screwdriver but with a pointed end) or nail to pull the sides of the screen into place. After all edges are nailed, stapled, or tacked in place, the molding is nailed over the screen flush with the inside edge of the frame. You can use a linoleum knife to trim the screen wire flush with the outside edge of the molding.

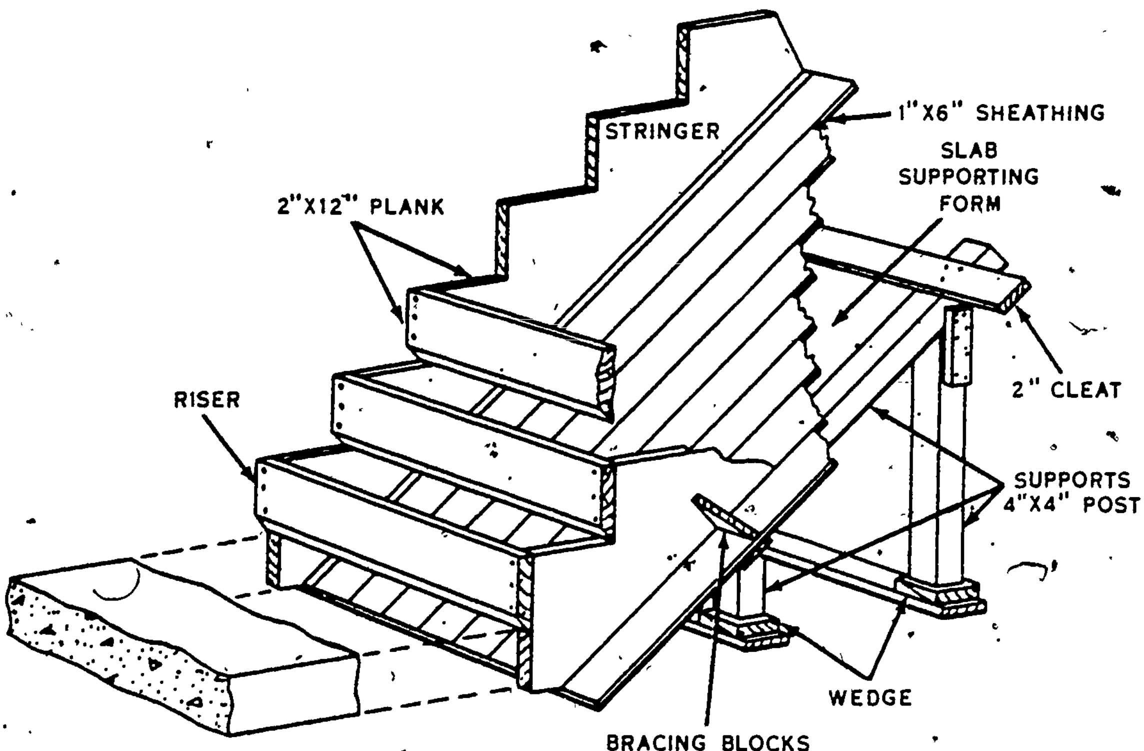



Figure 80. Porch stair form.

CHAPTER 3

# Roof Framing and Materials

ALTHOUGH THE roof of a building serves to protect the building and its occupants from various forms of precipitation and extremes of temperature, it is also important as a decorative feature.

2. The primary purpose of the roof on any building is to shed rainwater and snow. The roof must be constructed to shed water as quickly as possible; consequently, it should be sloped or inclined, although the most economical roof to build is one which is nearly flat. In cold climates snow may pile up on the roof, and unless special provisions are made for holding such a snow load, the roof may collapse.

3. The style of the roof is important when identifying a building with the architecture of a certain historic period or of various countries. In our country, straight lines seem to prevail.

4. It may be true that "you cannot judge a book by its cover"; however, it is also true that "first impressions are lasting impressions." The first impression of a building is largely influenced by the exterior of the building, including the roof.

5. Most military structures are designed for practical purposes rather than beauty. A building, however, does not need to be ugly to be practical. If you give the proper attention to construction, a building can be both useful and attractive. A few of the common types of roofs and the materials used to cover these roofs are discussed in this chapter.

## 9. Roof Framing

9-1. The framing of a roof is probably one of the most difficult jobs you will find in building construction. Although roof framing does not involve many complicated details, the fitting together of the various members will be difficult if each piece is not laid out and cut to the exact size. It is important that you be able to identify and know how to properly frame these parts to provide a roof that will serve the purpose for which it is intended, such as a protection against the cold of winter and the heat of summer.

9-2. Roofs can be classified according to their shapes or by the way they are constructed and supported. They may be of flat, pitched, sloped, or curved shapes. Roofs that are supported on exterior walls and at a ridge (or bear on some intermediate point) are usually referred to as frame roofs. Other roofs that are truss or arch supported and bear only on exterior walls, columns, or other trusses are called trussed roofs.

9-3. It is not necessary that the complete building be covered with a roof of one type. In fact, it is a common practice to use two types of roof framing and occasionally more on a structure. Further, you will probably recognize that some types of roofs are actually combinations of other simpler types.

9-4. Regardless of the type of roof, individual parts and pieces are required. We will discuss the framing members in some detail in this chapter, but at this point let's consider only those which are most important. In the case of the frame roof, the rafter is the main shape-forming and load-supporting member. A truss has individual parts but can also be considered as a complete member which serves the same purposes as a rafter.

9-5. **Types of Roofs.** A few of the common roof types, as illustrated in figure 81, are discussed in the following paragraphs. The simpler designs are more often used, but the complex roofs are explained because they are in existence and are useful for certain conditions.

9-6. *Flat roof.* A flat roof is very economical to construct because fewer materials are required. The surface of this kind of roof lies along a straight line from one wall of the building to another. Flat roofs are usually supported by a truss, but in some instances large solid beams may be used. A parapet wall is usually constructed with flat walls, as shown in figure 81.

9-7. *Shed or lean-to roof.* This is one of the simplest types of roofs. It is normally used for small sheds, porches, or other places where appearance is not a matter of great importance. When it is desirable to obtain shelter as cheaply

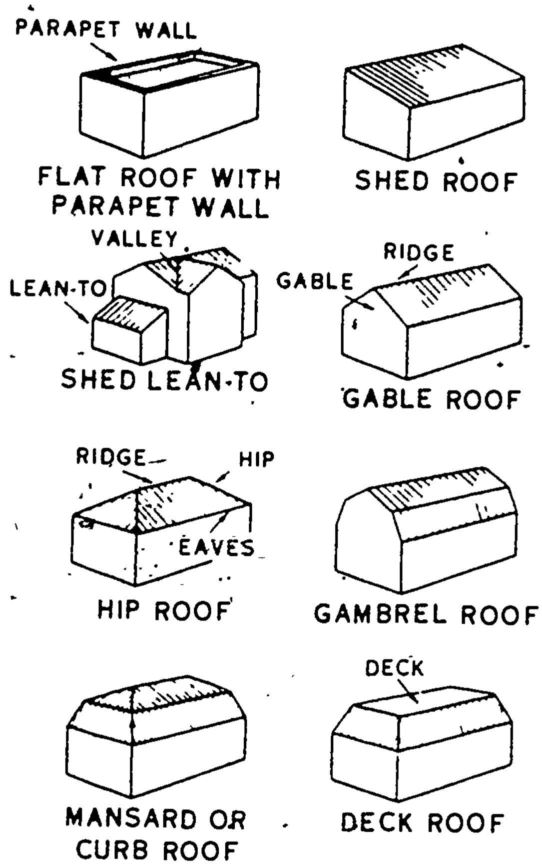



Figure 81. Common roofs.

and easily as possible, the shed roof may be used. The shed roof consists of a plain surface with one side or end raised to a higher level than the other side or end. The roof is supported in this position by means of two posts on one side and a wall, against which it leans, on the other side. It may also be supported by posts at all four corners. The position or slope of the surface enables water to freely drain at the lower side.

9-8. *Gable roof.* Gable roofs have two sloping surfaces, one on each side of the centerline of the building. These two surfaces form a gable as they come together in the middle of the roof at the ridge. Because of its simple design and low cost of construction, the gable roof is most commonly used on small houses. The pitch or incline of the gable roof may be varied from an almost flat surface to an extremely steep slope. The gable roof can be used in combination with other types and has often been the base of other roofs. This makes it difficult to distinguish the simple gable roof from other types which are often added to traditional roofs.

9-9. *Hip roof.* Hip roofs have four sides, all sloping upward toward the center of the building and terminating at a ridge. The line where the two adjacent sloping sides meet is called the hip. A rectangular building with a hip roof has a ridge. A square building is framed with the hips meeting at the highest point.

9-10. *Gambrel roof.* A gambrel roof is similar to a gable roof, except that it has a combination steep and shallow slant instead of the straight rafter. This type of framing provides more inside space than the gable roof.

9-11. *Mansard or curb roof.* This type of roof combines the framing and appearance of the hip and gambrel types.

9-12. *Deck roof.* A deck roof consists of a flat deck with steep slopes on each side.

9-13. *Intersecting roofs.* Intersecting roofs are formed whenever the ridges of two separate roofs are at an angle to each other. The two roofs may be of either the gable or the hip type, with the ridges at the same level or with one ridge lower than the other. The line where the two sloping surfaces meet is called a valley. Intersecting gable roofs are illustrated in figure 82.

9-14. **Roof Framing Terms.** Roof construction requires the use of terminology, or a set of names, all its own. These names, or terms, must be learned and understood before you can proceed with the framing of a roof. You will have a fuller understanding of these terms later, but the initial discussion of their meanings at this time will assist you in learning the procedures for roof framing. Study these explanations and definitions thoroughly.

9-15. *Ridge.* The ridge is the highest horizontal roof member which helps to aline the rafters and tie them together at the upper end, as shown at A of figure 83. The board which is used to form the ridge may be of 1- or 2-inch finished lumber. However, it is usually of the thickness of

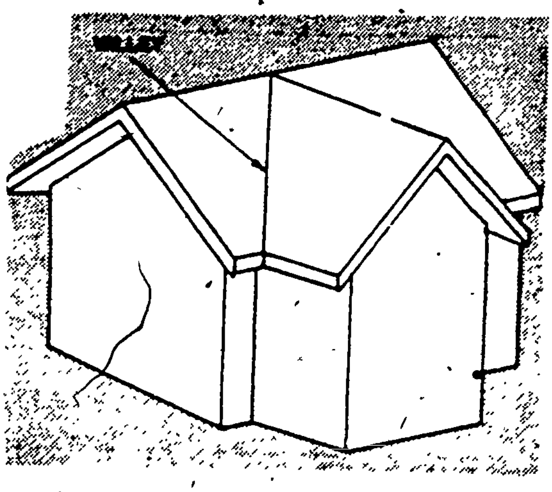



Figure 82. Intersecting roof.

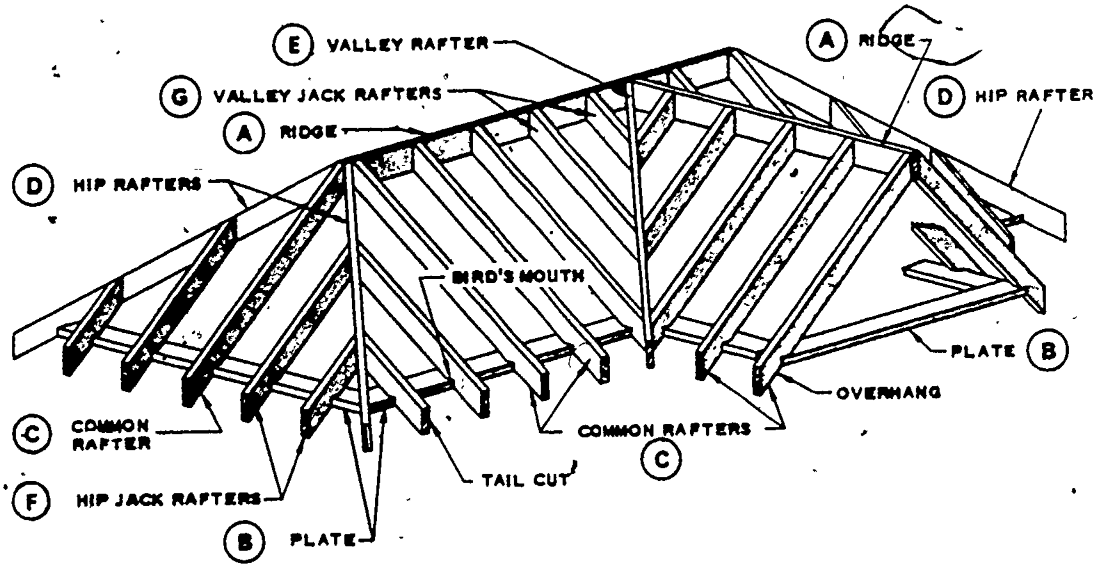



Figure 83. Roof framing terms.

the rafters and as wide as the cut on the end of the rafter.

9-16. *Plate.* This is the wall framing member that rests on the top of the wall studs. You will remember that we referred to it as the top plate in Chapter 2. We will sometimes call it the rafter plate, because it is the framing member upon which the rafters rest. B of figure 83 illustrates the location of the plate with respect to the rafters.

9-17. *Rafters.* Rafters are the sloping structural timbers of a roof which are designed to support the roof loads. Common rafters extend from the ridge to the plate, as shown in C of figure 83, and form the major portion of most frame roofs. They are to a roof what the joists are to a floor and what the studs are to a wall. In the construction of roofs, different kinds of rafters are used. These other kinds of rafters will be discussed a little later in this chapter.

9-18. *Overhang.* Often referred to as the lookout or tailpiece, the overhang is that portion of a rafter extending beyond the outside edge of the plate or walls of a building. When laying out a rafter, this portion is an addition to what is considered the length of a rafter and is figured separately.

9-19. *Bird's mouth.* The bird's mouth is a cutout near the bottom of a rafter which fits over the top plate, as shown at B of figure 84. There are other cuts for fitting a rafter to the plate, but this is a very common procedure. Notice on the illustration that the cut which fits the top of the plate is called the seat, whereas the cut for the side of the plate is referred to as the heel.

9-20. *Plumb and horizontal lines.* A plumb line is one that would be formed by the cord on which a plumb bob is hung. A horizontal line is one which is level with the foundation of a building. In cutting roof framing members, such as

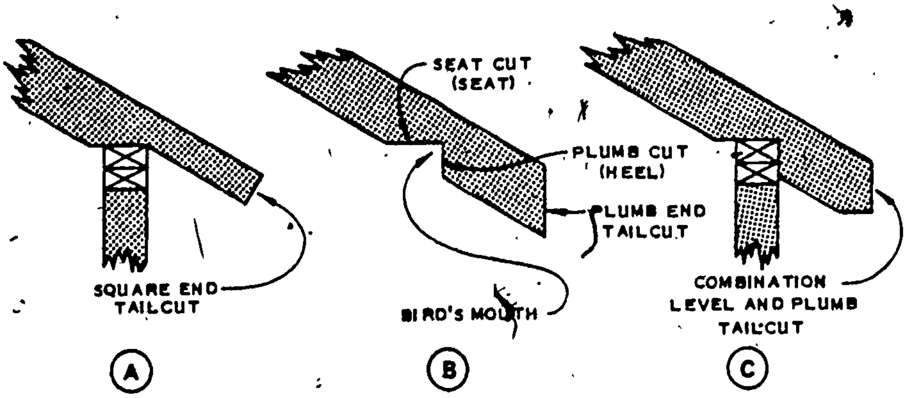



Figure 84. Cuts on bottom end of rafters.

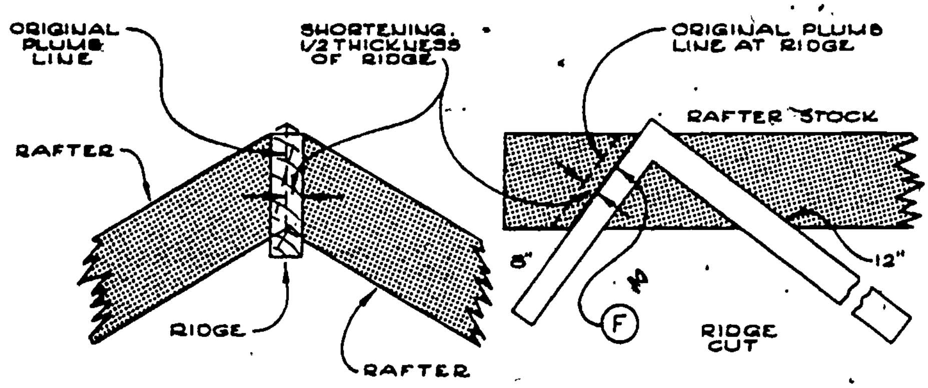



Figure 85. Ridge cut.

rafters, you will often need to imagine the direction of these lines when making plumb cuts or horizontal cuts. Notice that the heel and tailcuts of the rafters at B and C of figure 84 and the ridge cut of figure 85 are along an imaginary plumb line. Likewise, you will notice that the seat cuts of B and C and a portion of the tailcut of C on figure 84 are level, or horizontal. The same angle relationship must exist when you are laying out a rafter from material resting across sawhorses. If you will learn these relationships of lines and use your imagination well, you will experience little difficulty in building roof frames.

9-21. *Span.* The span is the spread of the roof or the distance from outside to outside of the top plates of the building. This span distance, as shown on figure 86, is always given on the blueprints. The span measurement can also be found by measuring the actual distance between the outside walls of the building under construction.

9-22. *Run.* The run is measured from a plumb line through the center of the ridge, or highest point of the rafter, to the outer edge of the plate, as illustrated on figure 86. With roofs of equal slant—as in the gable roof with the rafter plates at the same height—the run is equal to one-half the span, or one-half the width of the building.

9-23. *Rise.* The rise of a rafter is the vertical, or plumb, distance that a rafter extends upward from the plate. The rise can be measured vertically from an imaginary line, connecting the top of the plates to the ridge, as shown in figure 86. The rise is seldom shown on a drawing or blueprint of a building, but it can be found by scaling the drawing or by computation.

9-24. *Basic triangle.* The basic principle involved in roof framing is the right triangle, shown in figure 86. The base of this triangle represents level, or horizontal, lines of roof measurements. The altitude represents the plumb or vertical lines of measurement, and the hypotenuse represents the length of the rafters. When framing a roof, the basic right triangle is formed by the run, the rise (or altitude), and the length of the rafter (the hypotenuse). Any part of the triangle can be computed if the other two parts are known. Use the equation which indicates that the square of the hypotenuse of a right triangle is equal to the sum of the squares of the two sides. By stating this formula in roofing terms, the following is a

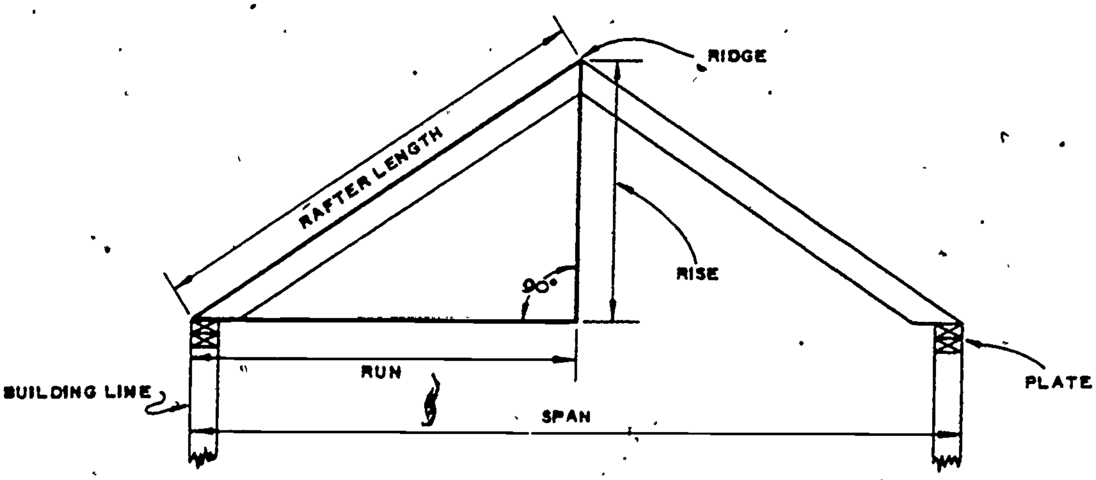



Figure 86. Right triangle.

better form of the equation: Rafter length$^2$ = run$^2$ + rise$^2$.

9-25. *Pitch*. Pitch is a term which is used to signify the amount that a roof slants. Units, or amount, of pitch are expressed as ratios. There are two methods of indicating pitch. Using the first method, the pitch is indicated as a ratio of the rise to the span of a roof. This ratio is stated as a fraction, as shown in A of figure 87. The units of span and rise must be the same (inches or feet), and the fraction is reduced to its lowest common denominator. With the second method, pitch is stated as the ratio of rise (in inches) to (or per) 1 ~~foot of span~~ (12 inches). Using this method, 4, 6, or 8 inches rise per foot of span would give a pitch of 4-12, 6-12, or 8-12, as shown in B of figure 87. Further examination of figure 87 shows that a roof with ½ pitch can also be said to have 12-12 pitch.

9-26. **Rafters.** There are four types of rafters: the common, hip, valley, and jack.

9-27. *Common rafters*. The framing members which extend at right angles from the plate line to the ridge of the roof are known as common rafters. They are so named because they are common to all types of roofs and are used as the basis for laying out other types of rafters.

9-28. *Hip rafters*. Roof members extending diagonally from the corner of the plate to the ridge, as shown at D of figure 83, are known as hip rafters. The hip rafters form the ridges or hips where adjacent slopes of the roof meet.

9-29. *Valley rafters*. Roof members extending diagonally from the plate to the ridge at the line of intersection of two roof surfaces, as illustrated at E of figure 83, are known as valley rafters. The valley rafter is so called because it is located where adjacent roof slopes meet to form a hollow or valley.

9-30. *Jack rafters*. Jack rafters are a part of a common rafter. There are three kinds of jack rafters: the hip jack, the valley jack, and the cripple jack. Two of these are shown at F and G in figure 83. The hip jack rafter extends from the plate to the hip rafter, whereas the valley jack rafter extends from the ridge to the valley rafter. A cripple jack rafter extends from a hip to a valley rafter. This rafter is also part of a

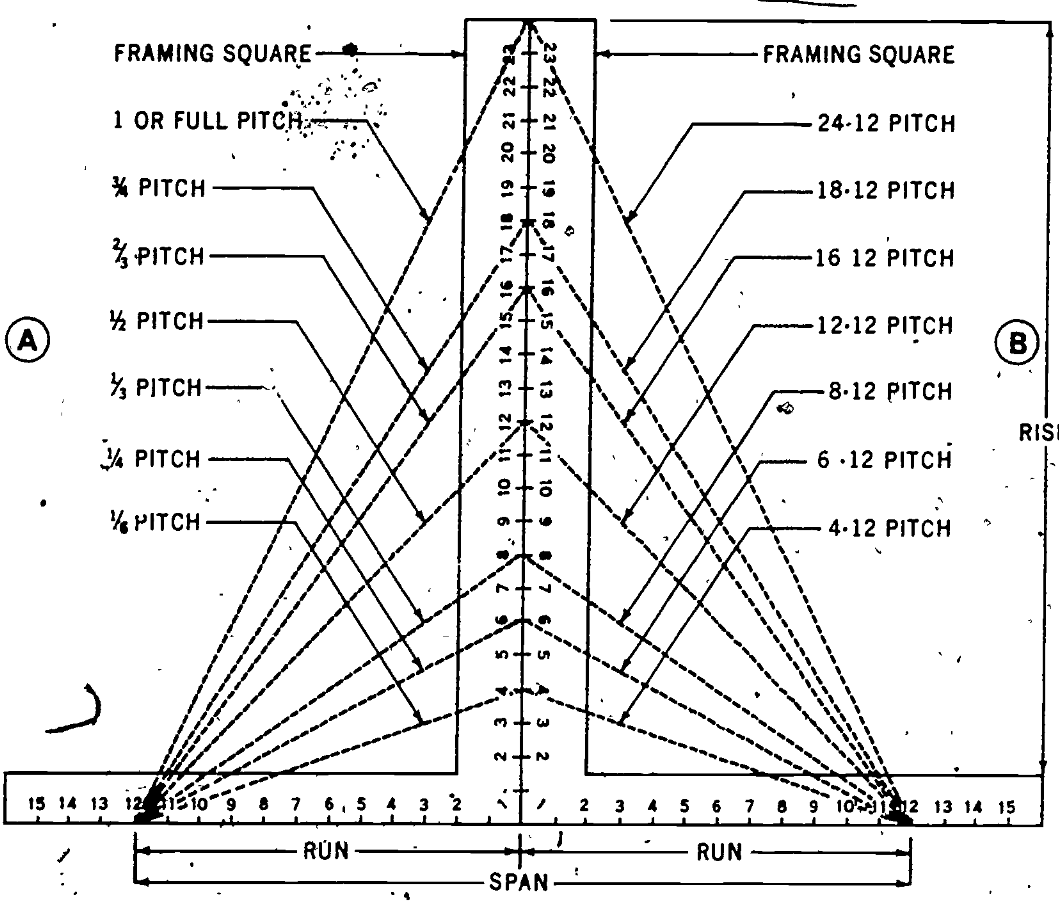



Figure 87. Units of pitch.

common rafter but touches neither the ridge of the roof nor the rafter plate.

9-31. **Laying Out Rafters.** There are several satisfactory methods for finding the length of and laying out rafters. We will discuss three of these methods which are often used. If at a later time you find that another method seems easier for you, do not hesitate to use it if correct work results.

9-32. *Basic triangle method.* With this method of determining rafter length, the rafter is considered to be the hypotenuse of a right triangle, as shown in figure 86. The vertical side of the triangle is the rise, and the horizontal side is the run. Let's assume that the rise of the roof, shown in figure 86, is 9 feet and the span is 24 feet. Using the equation for the basic triangle, we can solve for the rafter length, because the length of the sides of the triangle is known or can be determined. Although the run distance is not given, it can be determined as 12 feet (½ of the span). By substituting values, we find that rafter length$^2$ = run$^2$ ($12 \times 12 = 144$) + rise$^2$ ($9 \times 9 = 81$). By further computation, it can be seen that the rafter length $= \sqrt{144 + 81} = 15$ feet. Therefore, the length on the rafter, from the point on the ridge to the point at the outside of the plate, is 15 feet.

9-33. If the rafter has an overhang, the additional length must be computed. The amount of overhang is usually given as the horizontal distance from the plate to the end of the rafter. If this distance is known and the pitch of the roof is given, the rise can be computed. When the horizontal (run) and vertical (rise) measurements of the overhang are known, the additional rafter length can be computed by using the basic triangle equation. To find the total length of the rafter, discussed in the previous paragraph, let's compute the amount of additional rafter length required if the overhang is to be 1 foot and 4 inches (16 inches), as shown in figure 88. First, we must determine the pitch of the roof, using dimensions given in the previous paragraph. By dividing the rise of the roof in inches by the run in feet, we find the pitch: P = rise ($9 \times 12$) ÷ run (12) = 9 inches per foot (or per 12 inches) = 9/12. Now, with the pitch known, we can find the amount of rise (in inches) of the overhang along a horizontal distance (run) of 16 inches. Solving for rise with the equation just used, the equation appears as: Rise (in inches) = pitch (expressed as a fraction) × run (in inches). Then, the overhang rise = pitch (9/12) × run (16) = 12 inches. By placing these values in the basic triangle equation, we find: Rafter length (additional) $= \sqrt{\text{run}^2\ (16 \times 16) + \text{rise}^2\ (12 \times 12)} = 20$ inches. Therefore, the total length of the rafter

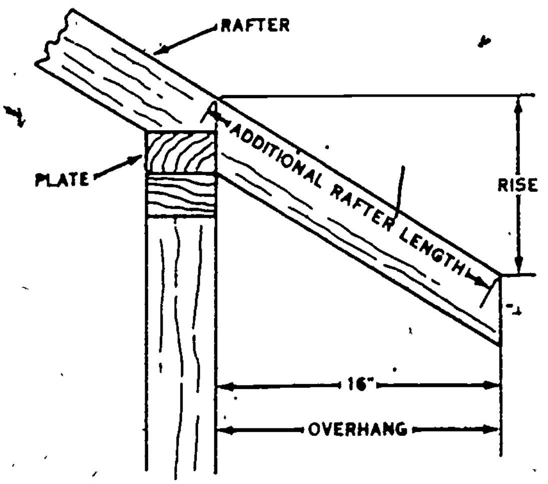



Figure 88. Additional rafter length for overhang.

equals 15 feet plus 20 inches, or 16 feet and 8 inches.

9-34. *Framing square table method.* Another method of determining rafter length is to use the rafter table which is located on the blade of many framing squares. The tables are laid out similarly to the tables used for board measure that are located on the opposite side of the blade of the square.

9-35. If your square has a rafter table, as shown in figure 89, the number given represents the length of the rafter per foot of run. On this square, you must first locate the section labeled "Length Common Rafters per Foot Run." One foot (12 inches) of run is assumed, so only the rise (in inches) is needed to find the rafter length per foot of run. If a rise of 10 inches per foot of run and a run of 6 feet is assumed, you will first locate the 6-inch mark on the blade. This 6-inch mark represents 10 inches per foot of rise. Just below the number 10, the number 1562 is shown. In this case, the 62 indicates hundredths of an inch. The number 1562 represents the length of a common rafter having 10 inches of rise and 1 foot of run. You may use this number in two ways to find the length of the rafter. You can multiply 15.62 times the number of feet of run, or you can set a pair of dividers with 15.62 inches between the points and step off the same number of steps on the rafter as there are feet of run. In the example there is 6 feet of run, so the rafter length (in inches) would equal 6 times 15.62 ($6 \times 15.62$) = 93.72 inches, or approximately 7 feet 9¾ inches).

9-36. The additional rafter length required for an overhang may be found separately by using the framing square tables. You will use the pitch of the roof and the run of the overhang (in feet). The total length of the rafter may also be found

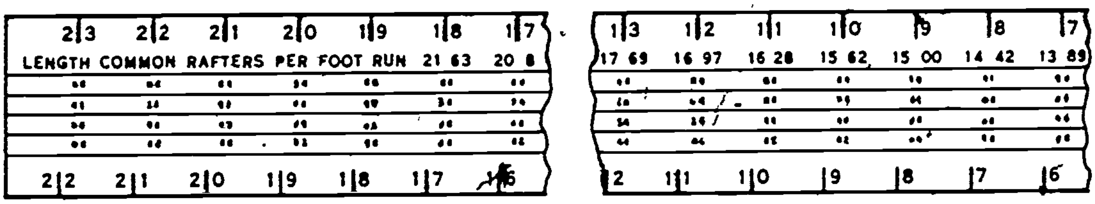



Figure 89. Framing square rafter table.

by first adding the run and rise of the overhang to the run and rise from the plate to the ridge.

9-37. *Framing square step-off method.* Another method of rafter layout is to use the square to step off the measurement. You will use the rise (in inches) on the tongue of the square and the 12-inch (1 foot) mark on the blade. The measurements on the outside of the blade and tongue are best used, and a marker may be used to indicate the applicable numbers. When using this method, hold the heel of the square with the tongue pointing away from you, and the blade to your left. Although it makes no difference at which end of the rafter you start, we will start at the upper (ridge) end to explain the procedures of stepping off a rafter.

9-38. Assuming that the pitch of the roof is 5-12 and that the run of the rafter is 6 feet, you place the square near the end of the rafter material, as shown in figure 90. The 5-inch mark on the tongue and the 12-inch mark on the blade are located on the lower edge of the rafter. A mark along the outer edge of the tongue will lay out a vertical line for the plumb cut as shown by position 1 on figure 91. Remember, all marks along the tongue indicate vertical lines, and all marks along the blade indicate horizontal lines as viewed after the rafter is raised into position. Make a thin mark or knife cut on the rafter where the outer edge of the blade meets the material. This completes position, or step, 1.

9-39. Slide the square along the edge of the rafter until the 5-inch mark on the tongue meets the edge of the rafter at the point marked in the first step. Mark the rafter where the 12-inch mark

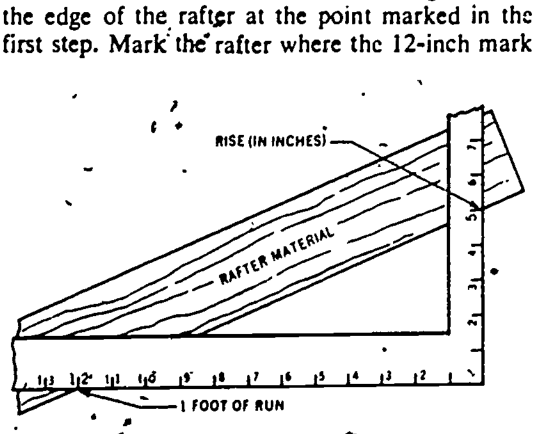



Figure 90. Positioning of square to step off a rafter.

on the blade meets the lower edge of the material. This completes step two. For a 6-foot run you need to make six steps, so repeat step two as indicated by positions 3, 4, 5, 6, and 7 in figure 91. The point marked by step 6 is the length of the rafter, but step 7 is necessary to mark a vertical line that indicates the outer edge of the top plate.

9-40. If an overhang is to be laid out on the rafter, it can be marked with the square in position 7. For instance, if the overhang is 12 inches, the end of the rafter would be at the point where the blade meets the edge of the rafter material. If the run of the overhang is some other distance, make a mark on the material where the measurement of that distance is indicated on the blade. Then, reposition the square, as in the previous steps, with the edge of the tongue on the mark just made. A vertical line marked along the tongue will indicate the bottom end of the rafter where the line meets the bottom edge of the material.

9-41. *Ridge cuts.* If the rafters on both sides of a roof are nailed to each other, the mark for the ridge cut is made along the square in position 1 of figure 91. However, a ridge board is usually placed between the ridge cuts, and the rafters are nailed to the ridge board. The ridge board may be of material which is either 1 or 2 inches in thickness. Regardless of which material is used, one-half of the thickness must be subtracted from the rafter length, as shown in figure 85 and at A of figure 91. This is done by measuring a distance equal to one-half of the ridge board thickness along a line which is perpendicular to the original plumb line. The ridge cut is then made along a line through the measured point and parallel to the original plumb line, or ridge cut. Cross out the old line to avoid making an error in cutting.

9-42. *Tail cuts.* Rafter tail cuts may be made in many different ways. Some of the more common cuts are shown in figures 84, 86, and 92. You will notice that all of the cuts are either vertical, horizontal, or a combination of vertical and horizontal. To mark these cuts, place the square in the same way explained when stepping off a rafter.

9-43. At A of figure 92, the vertical tail cut is marked along the tongue of the square, even with the outside of the plate. This rafter has no overhang. You will notice also that the seat of this rafter must be marked horizontally along the blade of the square. At B of figure 92, the tail cut is marked vertically at the end of a 12-inch overhang, whereas the cut shown at C of figure 92 is marked horizontally. D of figure 92 illustrates the marking of a combination vertical and horizontal tail cut on the overhang of a rafter. Other cuts may be marked with the square, using the same methods.

9-44. *Bird's mouth*. You will mark and cut a bird's mouth in a manner similar to that for marking tail cuts. The cuts may be of any depth which is not greater than one-half of the width of the rafter material. However, the common depth is 1¾ inches, or one-half of the thickness of a doubled top plate.

9-45. Refer to detail B of figure 91 and assume a 5-12 roof pitch for the following example of laying out a bird's mouth. A line drawn along the outer edge of the tongue in position 7 will be a vertical line, indicating the outer edge of the top plate. Leave the square in this position and mark the depth of the bird's mouth. For this example, a double 2 x 4 top plate calls for a bird's mouth with a depth of 1⅝ inches. The 5-inch mark on the tongue is already on the lower edge of the rafter, so you can mark a point on the rafter material at the 6⅝ (5 + 1⅝)-inch mark on the tongue. This measurement is made at this time to avoid the common error of measuring straight across the rafter instead of following the vertical line. By leaving the square in place at position 7, you will follow the correct line for measuring the depth. Now, slide the square back to position 8, which is to the right of position 6. In this position, the blade crosses the depth-indicating point on the material. Make a line across the blade to indicate the cut for the seat of the bird's mouth. This seat forms the part of the rafter which rests on the top of the plate.

9-46. This completes the layout of the common rafter pattern. Before cutting the rafter pattern, it is advisable to cross out all lines on the rafter pattern stock except the marks needed for making the cuts. This precaution helps to prevent errors when the various cuts are made. A crosscut handsaw should be used to cut the rafter pattern. When the rafter pattern has been cut, it can be used for marking the remaining rafters. If the cuts do not leave inside angles, you can save considerable time by using a power handsaw to cut these rafters. Where the cut to be made forms an inside angle, as in A and B of figure 84, you may use both powersaw and handsaw. The circular shape of the powersaw blade does not leave a straight cut through the board; therefore, after sawing to the intersection of the marks with the powersaw, you must finish the cut with a handsaw.

9-47. The layout and cutting of other types of rafters are done in a similar manner, using the same principles. Always remember that every cut is along either a vertical or a horizontal line.

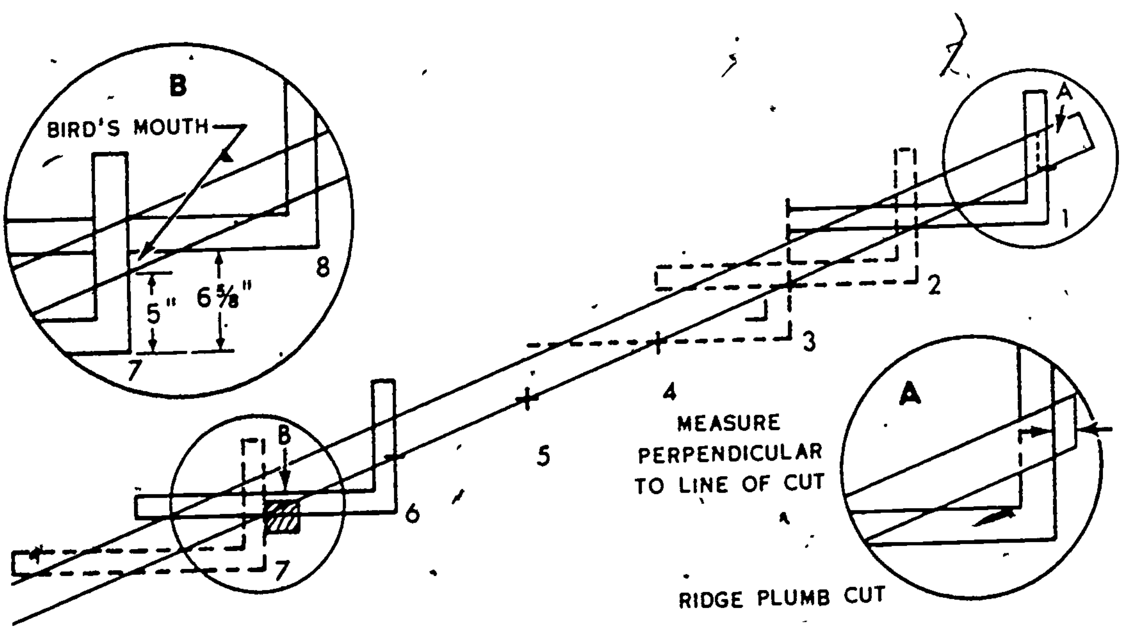



Figure 91. Step off rafter layout.

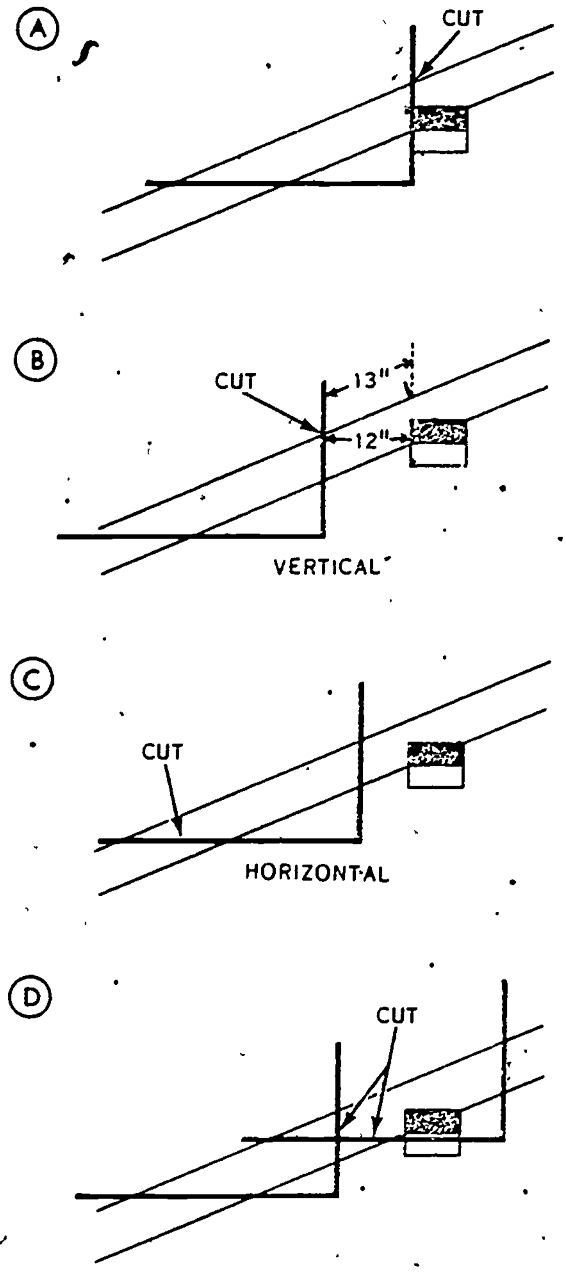



Figure 92. Rafter tail layout.

Ask your supervisor to assist you when complex problems arise.

9-48. **Spacing and Size of Rafters.** Now that we have examined the principles of laying out a rafter, let's discuss the spacing and size of the rafters.

9-49. *Spacing.* Since plaster and other interior finishes are not generally applied to the undersides of rafters, it is not necessary to adhere to the 16-inch spacing standard with joists and studs. Spacing is determined by the stiffness of sheathing between rafters, the weight of the roof, and the rafter span. Spacings from 16 to 24 inches are common. Steep roofs may require additional strength to withstand high wind velocities.

9-50. *Sizes.* The size of roof rafters will depend upon three factors: the span, the weight of the roof material, and the snow and wind loads. Generally, rafters are made of either 2 x 4's, 2 x 6's, or 2 x 8's. It is particularly important that they be straight, of good material, and large enough to stay that way. A sagging roof will not shed water and snow properly.

9-51. *Nailing.* The following recommendations are made in connection with nailing, placing, and anchoring rafters:

- The rafter should be notched over and should have a good bearing on the plate.
- Wherever possible, ceiling joists should run across the building to connect the base of the rafters at or near the plate.
- A ridge board should be provided to aid in the erection and alinement of rafters.
- Be sure to provide adequate bracing from rafter to rafter and from rafters to ceiling joists.

9-52. Nailing, especially of ceiling joists to rafters, is important if there is not much slope to the roof. The nailing at the ridge is not of great structural importance. Its chief function is to hold the rafters in position during construction. It is not uncommon to assemble the rafters on one side of a ridge board first and nail through the ridge board into the rafters, using 16d common nails. The rafters on the other side are then set into place, either toenailed against the ridge board or slightly offset with respect to the rafters opposite. This permits nailing through the ridge board from both sides. The latter method is preferable. The only objection to this procedure is that it may look a little unworkmanlike. But it probably makes a better job if the offset is just enough to permit thorough nailing. Where a ridge board is not used, the two rafters which join at the ridge are sometimes assembled with interconnecting braces on the ground. After assembly, they are hoisted and placed on the plates as a unit. Regardless of the method of placing the rafters must be securely fastened to the plates. One 16d or 20d nail can usually be driven from the top of the rafter through the seat cut into the plate. At least one additional 16d nail should be toenailed from each side of the rafters into the plate. When possible, place rafter to ceiling joist braces over bearing partitions. These braces may be of either 1-inch or 2-inch material, depending upon the strength required.

9-53. Now that we have studied rafter layout and installation, we will examine some special roof framing.

9-54. **Dormers.** Any type of window protruding from a roof is called a dormer. Its purpose may be to provide light on the upper floor or to add to the architectural effect of the building. It may be considered a minor roof in comparison with the major roof span. In some cases, dormers may be constructed to improve the exterior appearance of the building and to provide additional space in the interior of the building. A dormer may be built up from the level of the main roof plate or from a point above the plate. The front wall of a dormer may be set back from the main building line, it may project beyond it, or it may be flush with the building line.

9-55. In many instances, dormer roof surfaces are of the same general shape as those of the main roof. The dormer does not necessarily have to carry out the main roof lines unless it is built for appearance only. Dormers constructed for the purpose of providing additional space within the building are generally of the style that will provide the most headroom. The plate line of the dormer may be raised above that of the main roof so that additional headroom is provided.

9-56. Figure 93 shows the appearance of a shed dormer. The rafters for a shed dormer are laid out and spaced the same as a common rafter of the main roof, using the rise from the top of the dormer plate to the top of the header between the main roof rafters. The run of the rafter is taken from the outside of the dormer plate to the front face of the header.

9-57. Figure 94 illustrates a gable dormer. This type of dormer sheds rain and snow in two directions, and is often used in preference to a shed dormer when it is necessary to provide more pitch or to carry out the general lines of the main

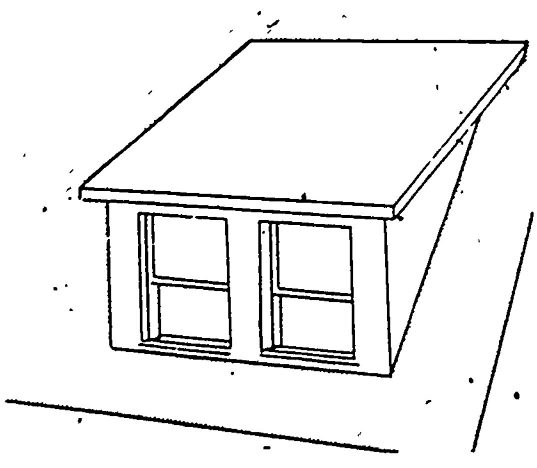


**Figure 93. Shed dormer.**

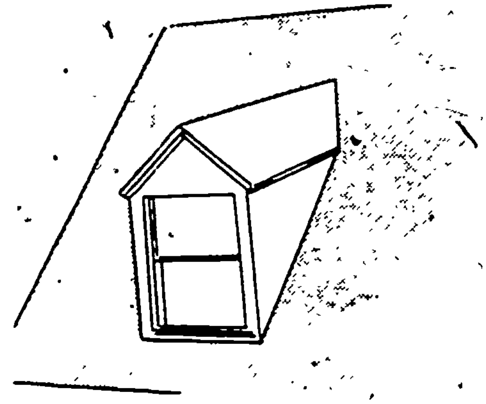


**Figure 94. Gable dormer.**

roof. The rafters for this type of dormer are laid out in the same manner as the common rafter.

9-58. **Framing for Roof Openings.** Chimney holes, heating and plumbing openings, skylights, and scuttles are framed in roof rafters in a manner similar to that for openings in floor joists. The headers between the rafters are placed so that their faces are plumb. The opening in the roof rafters is located by plumbing up from the face of the headers and trimmers of the opening in the floor joists and by placing headers between the rafters, as shown in figure 95. When a chimney hole, a scuttle, or a skylight is to be located, a plan of the opening can be drawn full size on the attic floor. The points showing the inside dimensions of the opening are then plumbed up to the rafters or to boards temporarily nailed to the roof.

9-59. **Gable and Hip Cuts of Frame Members.** So far we have discussed rafters and rafter problems. This information can also be applied to other work. Figure 96 shows some gable sections with a square placed on them to remind you of other uses for the square. You use the pitch numbers on the tongue and blade of the square just as you did for rafter layout. You place the square on a piece of siding just as though you were going to make a square cut across it. In this position the inside edge of the blade is flush along the bottom edge of the board, and the tongue extends across the board. Place one edge of a straightedge in line with your pitch numbers (let's use 5 and 12 again) and hold it securely in place. Make a mark along the straightedge to make a diagonal line across the piece of siding. When you cut the board on this line, it will fit in a gable and match the slope of the roof having a 5–12 pitch, as shown in figure 96,A.

9-60. A gable stud can be laid out by placing the inside edge of the tongue on the edge of the material and letting the blade extend across the

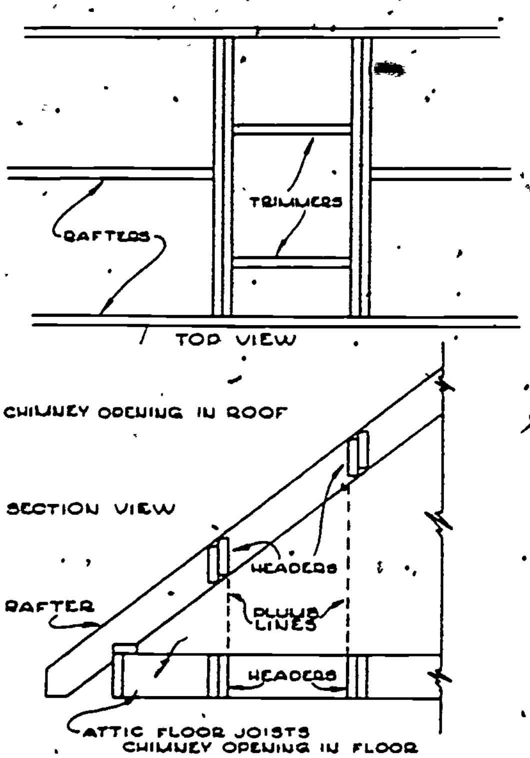



Figure 95. Headers and trimmers for roof openings.

material as though you were going to mark a square cut. Place one edge of a straightedge in line with the pitch numbers and make a mark across the material to indicate a diagonal cut that will match the slope of the rafter, as shown in figure 96,B.

9-61. Figure 96,C, shows the layout for a louver. The square is used to mark end cuts on the gable studs, headers, and siding, or on any part of the louver.

9-62. Figure 96,D, reminds you again that 12 is always the constant number that represents the run when you are laying out common rafters, or studs and siding that are placed against them. A hip or valley rafter extends diagonally from a top plate and is longer than a common rafter in the same part of the roof. To make up this added length and still retain the same number of steps of the square in layout work, you always use 17 inches on the blade to represent the run. Compare these measurements in figure 96,D.

9-63. So far in our discussion we have remained with the problems in light frame structures. Let's look at some of the problems in heavier frames, where trusses are used to support roof loads.

9-64. **Trussed Framing.** Trussed framing is generally heavier than rafters and is used over long spans. Some common types of trusses are shown in figure 97 to help you establish the layout of members. All truss framing is designed with wind pressure and snow loads considered, as is evidenced by the braces (webs) used in the trusses.

9-65. The Pratt truss, shown in figure 97, is commonly used for long spans of up to 120 feet. The bowstring truss is generally found in small hangers, warehouses, and recreational buildings. The Fink, scissors, and related types of trusses are used where the span is short, usually 60 feet or less. They are found in recreation, chapel, subsistence, garage, barracks, and similar types of structures.

9-66. *Truss parts.* The parts of a truss usually consist of an upper chord, lower chord (horizontal supports), and vertical and diagonal webs (between chords). The wood members are fastened together with bolts. Timber connectors, similar to those shown in figure 98, are seated between the framing members. A special cutter similar to a hole saw is required to seat the split-ring connector into the face of a chord or web.

9-67. *Purlins.* Usually when trusses are used to support a roof, they are spaced at much

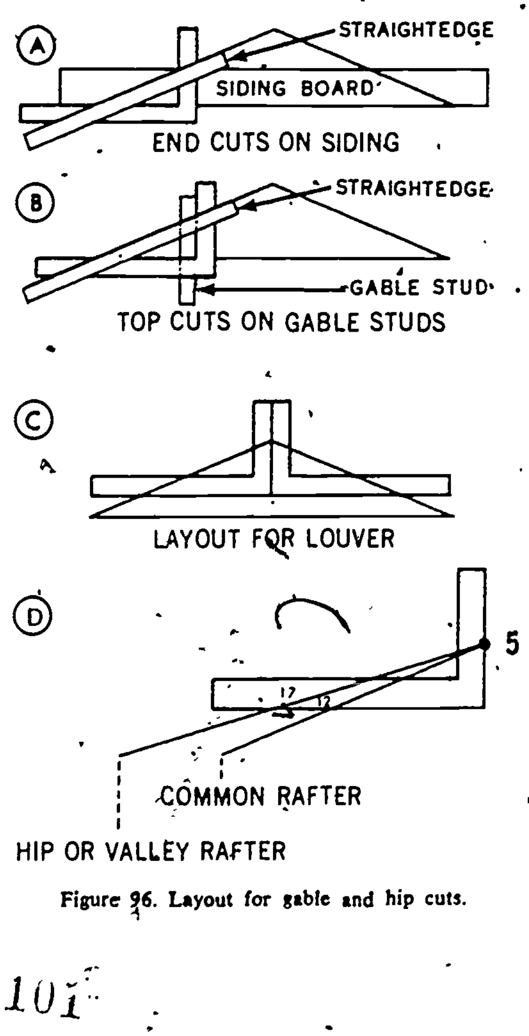



Figure 96. Layout for gable and hip cuts.

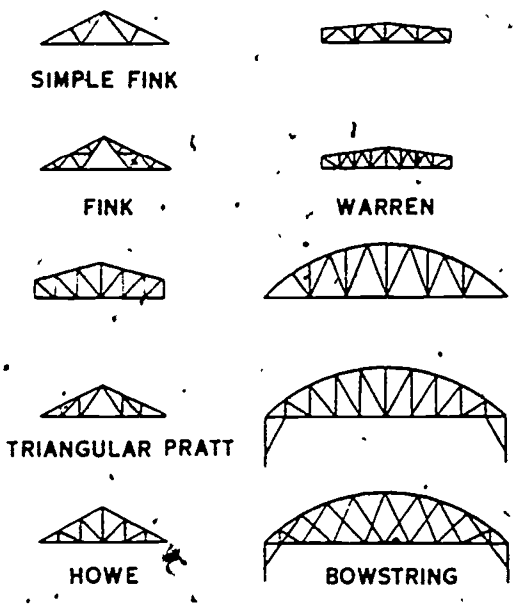



Figure 97. Trusses.

greater intervals than ordinary frame rafters. Often these intervals are from 10 to 20 feet. In these instances, purlins formed of metal beams or heavy wooden timbers are used to bridge in between the trusses, as shown in figure 99. Further framing may be installed over the purlins. This framing is ordinarily of 2-inch lumber and is installed like ordinary rafters.

9-68. Now that you have a knowledge of the principles and procedures concerning roof framing, we will proceed to the subject of roof coverings. It is certain that more maintenance is required to keep the surface of a roof in good condition than is required for the framework. However, if the covering should leak for any extended period of time, the framework will deteriorate also.

## 10. Roof Covering Materials and Accessories

10-1. Roof coverings are intended to shed water from a roof surface and prevent moisture from entering the building. There are many types of materials used. Some of the materials are intended to last less than 10 years, whereas others may be expected to last longer than the exterior wall coverings and trim. Of the available types, the military services use rolled roofing, asphalt shingles, built-up roofing, asbestos, slate, and tile for covering the roofs of their buildings and structures. In some cases, you may find wood shingles in use, but these are usually replaced, as repair is required, with a fireproof type.

10-2. Whether ordinary rafters or trusses are used for framing a roof and regardless of the type of covering installed, some type of sheathing or decking must be first placed over the frame. In general, you may use the same type of 1-inch boards or plywood for roof decking as is used for subflooring and wall sheathing. The boards are usually installed across the rafters or other similar framing members. The decking should have good nail-holding characteristics and must be well nailed, since the roof covering is nailed to the decking rather than to the frame member. With certain types of roof-covering materials, a particular type of decking may be specified.

10-3. Let's examine the procedures for installing each of the types of roof coverings in some detail. After you have a good understanding of these procedures, you will be prepared for our discussion of methods for maintaining roofs.

10-4. **Rolled Roofing.** Rolled roofing is commonly used for temporary construction because it is inexpensive and easily installed. It is a composition material which comes in rolls about 3 feet wide and in various lengths, depending on the thickness of the material. Rolled roofing usually weighs 90 pounds per roll. A can of lap cement (asphalt tar) and a package of roofing nails are usually included in the center of each roll.

10-5. The various brands, composed of either paper, felt, or asbestos, are all saturated with some type of waterproof compound. The exposed

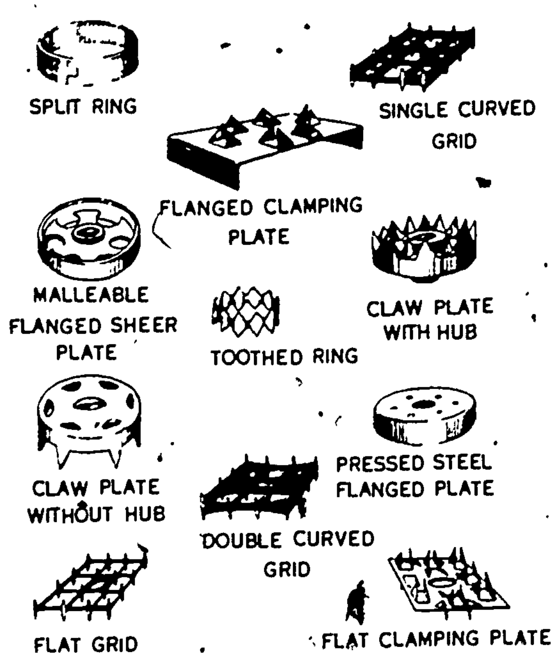



Figure 98. Timber connectors.

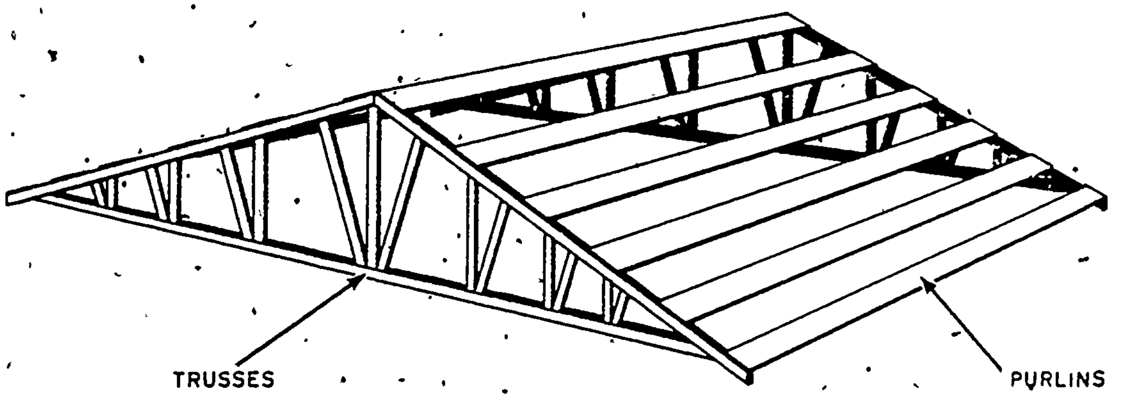



Figure 99. Trusses connected by purlins.

surface has a coating of either slate, sand, mica, or some similar material which helps prevent damage from hot sparks or heat from the sun.

10-6. Rolled roofing must always be stored standing on end to prevent shifting (rolling) and puncturing the material. Ordinarily, rolled roofing would not be used on a roof where the slope is less than 2½ inches per foot. It should be installed when the weather is clear, the temperature is at least 50° F., and the surfaces are completely dry. The roof deck must have solid sheathing of sound lumber. Knotholes or loose knots must be covered with sheet metal. Nails which extend above the roof must be driven flush with the surface or removed completely to prevent puncturing the roofing when it is put in place.

10-7. Rolled roofing must be installed in courses, or rows, starting at the eaves and working up the roof. The roofing material must extend approximately 2 inches beyond the sheathing at the gable edges and at the eaves. This allows the roofing to be turned down neatly for water drainage. Roofing nails spaced approximately 6 inches apart will be driven though the roofing into the edge of the sheathing boards. The application of wooden strips, as shown in figure 100, is specified for extremely windy areas.

10-8. The top edge of each strip will be nailed with roofing nails, driven through tin or fiber discs.

10-9. Each strip must overlap 4 inches on the preceding strip. The lap must be cemented with hot asphalt or cold applied sealing compound and secured with roofing nails. The nails should be spaced 6 inches apart and 2 inches from the edge, as shown in figure 101.

10-10. In order for you to safeguard against wind damage, the ends of the strips of roofing

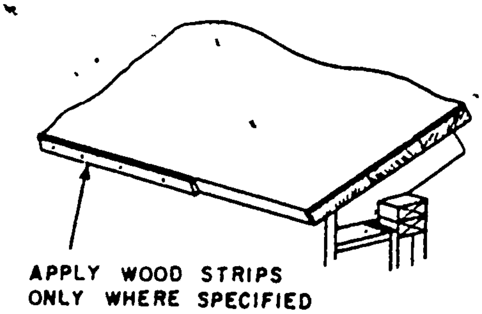



Figure 100. Applying wood strips.

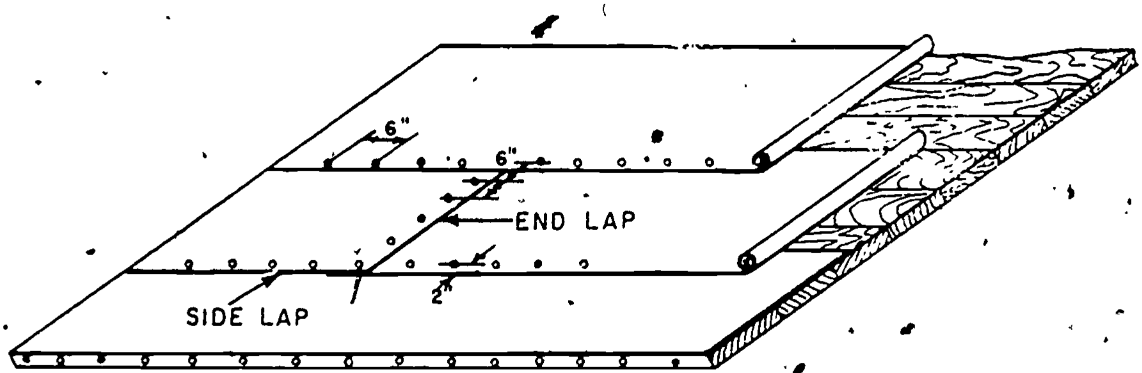



Figure 101. Spacing of nails.

204

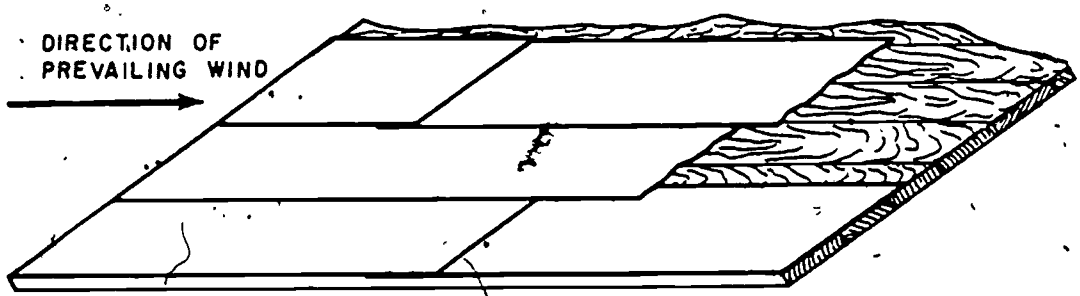



Figure 102. Overlapping ends of rolled roofing.

should be lapped a minimum of 6 inches in the direction of the prevailing wind, as shown in figure 102. The end lap should be sealed with lap cement and fastened with roofing nails spaced a minimum of 6 inches apart and approximately 2 inches from the exposed edge.

10-11. The ridge and hip should be covered with a double layer of roofing material, and each layer cemented and nailed every 6 inches on both slopes. Although the pieces used for covering the ridge or hip must extend down each slope 4 inches, they are usually cut 12 inches wide.

10-12. You should follow the manufacturer's instructions, packed in each roll, regarding the installation of rolled roofing when other specifications are not available.

10-13. **Asphalt Shingles.** Two types of asphalt-strip shingles have been accepted as standard for roofing mobilization-type buildings with sloping roofs. One of these types, shown at the top of figure 103, is a standard-weight, four-tab, 10" x 36" shingle intended for a 4-inch maximum exposure. The other type, shown at the bottom of figure 103, is a thick-butt, three-tab, 12" x 36" shingle intended for a 5-inch maximum exposure. Asphalt shingles are purchased by weight from 210–235 pounds per square. A square is the amount of roofing material needed to cover an area of 100 square feet.

10-14. When you are installing asphalt shingles, a starting strip must be applied at the eaves. This starting strip must have granules of the same type and color as the shingles. When shingles having a different color on the bottom part are used as a starter, they must be applied with the cutouts toward the roof top and the first course doubled. The cutouts on the exposed course are centered on the tabs of the under course, with the cutouts in each alternate course directly in line. The joints between courses are staggered by starting the first course with a full shingle. The next three courses are started with shingles one-half tab shorter than each preceding course, as illustrated in figure 104. The edge of the first shingle in the first course is flush with the side of the roof, and the tabs project approximately ¾ inch below the edge of the sheathing. The sides of the shingles at the edge of the roof are cut off flush with the tab. To complete each course, full width shingles are applied so that the ends barely touch each other. The portion of the shingle cut off to start a course can often be used at the opposite edge of the roof to complete the course.

10-15. Two galvanized roofing nails are placed approximately ¾ inch above each cutout and in the same relative position at each end of the shingle, as shown in figure 105. Nailing will start at one end of the shingle and proceed regularly to the other. Care must be taken to keep the butts alined with the top end of the cutouts in the course below. When laying thick-butt shingles, always nail through the thick portion. Practically all difficulties experienced with this type of shingle have resulted from nailing too high on the shingle. In windy areas the tabs are often cemented down.

10-16. Ridges and hips are finished with individual shingles provided by the manufacturer, with single shingles cut from strip shingles, or

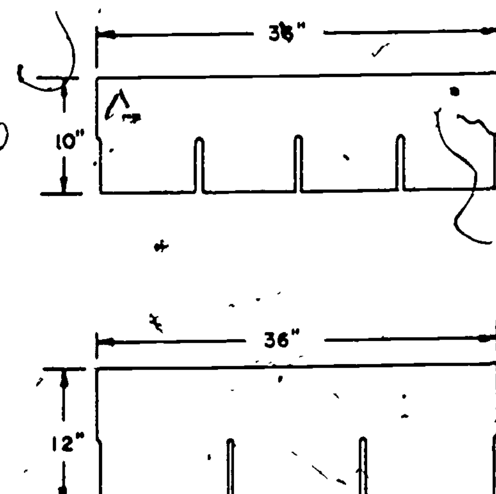



Figure 103. Types of shingles.

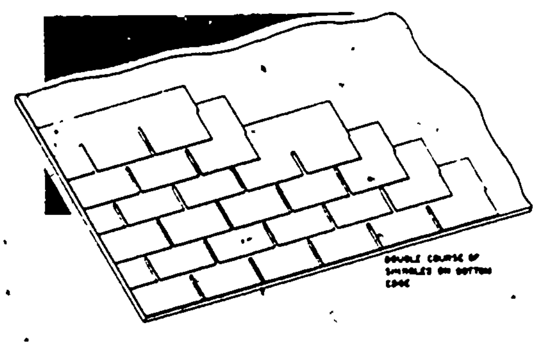


Figure 104. Placing of shingles.

with strips of mineral surfaced rolled roofing. Individual shingles on the hip or ridge have the same exposures as the other shingles on the roof. They should extend equally on each side of the hip or ridge, with one nail on each side about ¾ inch from the edge. When placing shingles on the ridge, always work in the direction opposite the prevailing winds.

10-17. **Built-Up Roofing.** A built-up roof consists of a membrane built up on the job with alternate layer of bituminous saturated felt and bitumen. Because each roof is custom made, the importance of good workmanship cannot be overemphasized. The bitumen which is used as a plying cement and as a coating for the saturated felts may be either asphalt or coal tar pitch. Coal tar pitch is particularly adaptable for "dead level" build-up roofs on which water tends to stand. Asphalt is better suited for built-up roofing on steeper slopes. The two can usually be distinguished by their odors. Asphalt has a distinct, oily odor, and coal tar pitch has a pungent, phenolic odor. These ordors can be determined best in fresh broken specimens or from the fumes of specimens which have been heated.

10-18. The layers of felt in a built-up roof function primarily to hold the layers of bitumen in place. They do not materially contribute to the waterproofness of the roof and are not suitable for prolonged exposure to the weather. Built-up roofs are designated by the number of plies they contain; for example, 3-ply and 5-ply roofs contain 3 and 5 plies of felt, respectively. They may also be designated as 10-, 15-, or 20-year roofs. A 20-year roof usually contains 5 plies of felt, 15-year roof contains 4 layers of felt, and a 10-year roof contains 3 layers. Built-up roofs may be applied to a variety of deck materials, including wood, concrete, and steel, with or without insulation. These roofs, when finished, may be smooth surfaced with a thick coat of bitumen; or they may be covered with a layer of mineral surfacing material or crushed stone. Surfacing materials for built-up roofs serve three important functions, they permit the use of a thick coating of bitumen, protect the bitumen from sunlight and heat, and increase the fire resistance of the roofing. Built-up roofs are not intended to carry foot traffic. Tile surfacing or wooden walkways should be used on roofs that are subject to regular traffic.

10-19. Asphalt must not be heated above 425° F. and must not be poured or mopped at temperatures under 350° F. Coal tar pitch should not be heated above 400° F., and its temperature normally should not be lower than 350° F. when poured or mopped onto a roof. Dense yellow fumes from the heating kettle are proof that the coal tar pitch is too hot.

10-20. The final coating of asphalt or coal tar pitch on a mineral surfaced roof will always be poured rather than mopped to assure sufficient bitumen for embedding the surfacing.

10-21. Operating instructions for heating kettles will not be discussed here because of the different types of kettles in use and the safety factors involved. The kettle is assigned to the pavements or carpentry section, and these sections will provide you with a qualified operator to use the kettle. If it becomes necessary for you to help operate a heating kettle, you must study the manufacturers' operating handbooks and be

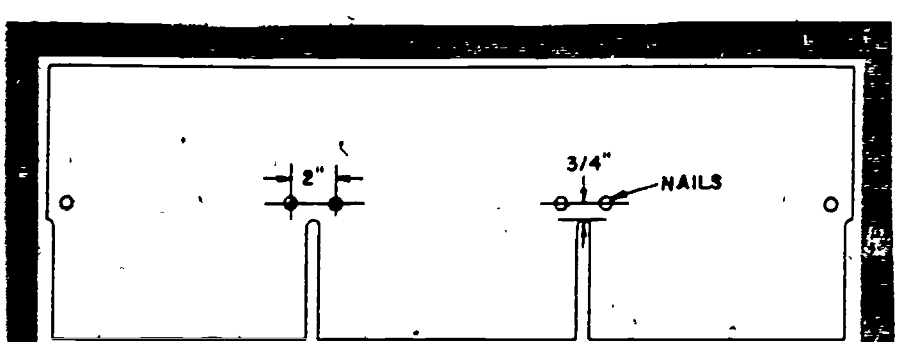



Figure 105. Nail positions for alphalt shingles.

prepared to make important decisions affecting the safe and efficient operation of the unit.

10-22. **Metal Roofing.** Metal roofings are classified into three general types:, flat sheets, corrugated sheets, and unit roofings made in the form of shingles or tiles. Special shapes of some metal roofings are shown in figure 106. Most metal roofing is bent to form ribs that add strength to the length of the sheet.

10-23. Flat metal sheets are assembled for roofing purposes by means of various seams, commonly designated as batten seams, standing seams, and flat seams.

10-24. In batten-seam roofing, the metal sheets are formed with ribs that provide for expansion and contraction in the direction perpendicular to the ribs. Expansion and contraction in the direction parallel to the ribs is provided by unsoldered flat-lock cross seams. Soldered cross seams are sometimes used with the expectation that allowance for expansion and contraction is made at the eaves and ridge, or that the soldered seams so stiffen the sheets that slight buckling within each sheet will occur during high summer temperatures.

10-25. Standing-seam roofing is similar to batten-seam roofing because it provides for expansion and contraction in the direction perpendicular to the seams. The roofing sheets are fastened to the roof deck by means of cleats (spaced not more than 12 inches apart) nailed to the roof sheathing at one end and folded into the seam at the other. Because standing seams are unsoldered, they are not used on roofs with slopes of less than 3 inches per foot and should preferably be used with slopes 4 or more inches per foot.

10-26. Flat-seam roofing, forming a continuous sheet, is adaptable to low-pitched roofs, preferably not less than ½ inch per foot, to assure proper drainage. Small sheets, usually 14 x 20 inches are fastened to the roof deck by means of cleats, one end of which is soldered to the sheet and the other nailed to the roof deck. A flat-lock seam is then formed at the juncture of the sheets, and the seams are sealed with solder. Although the sheets are held firmly in place by the cleats and sufficient elasticity is provided to take care of expansion and contraction, large roof areas covered by this method should have the extremities of the roof covering free. If not, expansion joints must be provided at regular intervals. Occasionally, long sheets of roofing are applied by the flat-seam method.

10-27. In corrugated roofing, series of parallel, alternate ridges and grooves or crests and valleys are formed in flat metal sheets. These features add stiffness to the sheets, increase the load-carrying capacity, and aid in discharging rainwater.

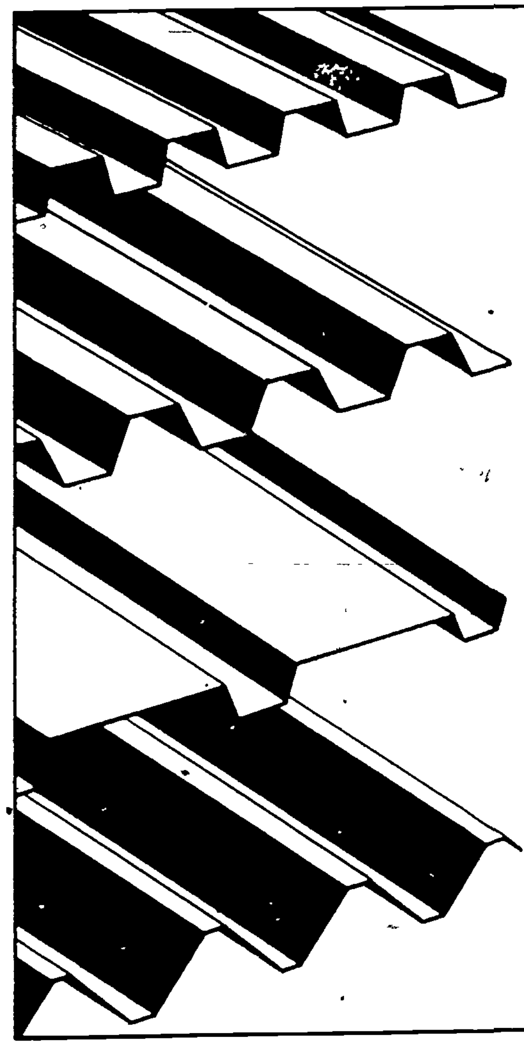


Figure 106. Metal roofing.

10-28. Metal shingles made to simulate the appearance of slate and tiles comprise most metal unit roofings. Because of the small size of unit roofings, no provision for expansion and contraction is necessary.

10-29. Corrugated galvanized roofing is the lowest in cost of all types of metal roofing; when properly applied and maintained, it renders satisfactory service. Because corrugated galvanized roofing is used most frequently on warehouses and sheds, it is representative of the galvanized metal roofings.

10-30. Corrugated galvanized roofing may be applied over tight wood decks with or without underlay, on open-slat decks, or on wood or steel purlins.

10-31. **Asbestos-Cement (Asbestos) Roofing.** Asbestos-cement shingles are used on roofs with at least a 4-inch rise per foot run; asbestos-cement sheets are used on slopes of 3 or more inches per foot. This material is quite brittle and becomes more brittle with long exposure to weathering. It is composed entirely of inorganic materials, portland cement and asbestos fibers, and is extremely resistant to normal weathering.

10-32. Asbestos-cement shingles are applied to a solid deck that is covered with an underlayment of 15-pound asphalt-saturated felt. The underlayment provides a cushion for the shingles and guards against the infiltration of wind and rain.

10-33. Corrugated asbestos-cement sheets are normally laid over open wood or steel framing. The sheets are fastened to horizontal purlins that are fastened to the top of rafters or trusses. Some common fasteners are shown in figure 107. Lead head nails and lag screws are also used. Plastic washers and calking are used to seal around the nailheads and boltheads.

10-34. **Slate Roofing.** Slate is a natural rock that was formerly much more widely used as a roofing material than at present. Consequently, most slate roofs that you encounter will be old ones on permanent structures. Some of the oldest roofs in the country are of slate, because slate roofing has been produced for more than 200 years.

10-35. Roofing slate is quite brittle and becomes more brittle on exposure. It is produced in a variety of sizes and is usually laid by the half-lap method. Roofing slate is normally $\frac{3}{16}$ inch thick, but on large structures it may range in thickness from $\frac{3}{16}$ to more than 2 inches for architectural effect. Slate roofs may vary in weight from 650 to 8,000 pounds per square, depending upon the thickness.

10-36. Slate is placed on a solid deck with a 30-pound asphalt saturated felt underlayment forming a cushion under the slate. Slate of poor quality, placed on a poor deck may last less than 25 years; while good quality slate may last more than 100 years under conditions of ordinary exposure, assuming that the slate is relaid when the fasteners begin to fail.

10-37. **Tile Roofing.** Most roofing tiles are clay or shale products that are burned to a hard, dense structure, with or without a glazed exposed surface. Some cement tiles are also in use. Several types of tile are used for sloping roofs, including shingle, Spanish mission (half-round), and interlocking; but in these general types there are many variants in size, form, and color. So-called promenade tiles are used to make a surface for foot traffic on built-up roofs. This tile is square-edged and at least ¾ inch thick.

10-38. **Roof Maintenance.** When a roof fails, costly damage can be done to walls, floors, ceilings, and equipment. You will be able to prevent the complete failure of roofs by performing timely inspection and repair. If a complete replacement must be made, the procedures you will use are practically the same as those we previously discussed for installing a new roof. However, only partial replacement will be required in most instances.

10-39. Often damage to roofs caused by hail, wind, and other weathering will be confined to the covering material. Sometimes the damage will be heavy enough to require replacement or repair of framing members. First we will discuss some of the maintenance tasks for rafters and trusses, then the covering materials.

10-40. *Repairing of roof framing.* Rafters are generally more accessible to inspection than other members of a wood frame building because they are usually uncovered on the underside, and defects and failures can be visually detected. Warped, twisted, or broken rafters can be replaced; or if the roof deck is sound, the rafters may be repaired. A warped or twisted rafter can

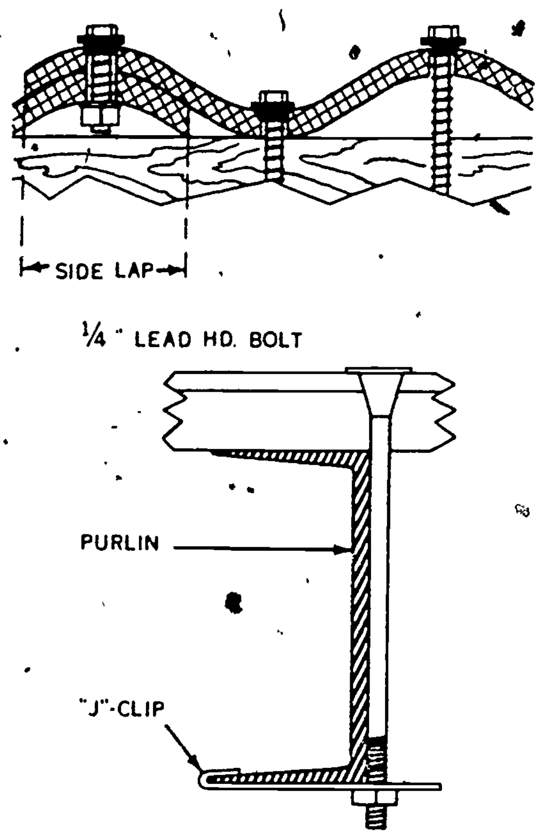



Figure 107. Fasteners for asbestos-cement corrugated roofing.

208

be straightened by adding solid block bridging between it and the rafters next to it. Broken rafters can be repaired by nailing splices along the sides. In some cases you may need to install additional support under the rafters. This support should extend from a ceiling joist to the rafter and be set at a right angle to the underside of the rafter.

10-41. When repair or replacement of rafters is required, you can usually copy the angles from the old rafter by using a T-bevel square. When this is not possible or convenient, you can determine the length and cuts of the rafters by one of the methods which we previously discussed. Replacing members of a truss is a task that requires supports and equipment that will prevent the truss from sagging or dropping. Maintenance crews should report to their supervisor conditions that require replacement of trusses or parts of a truss. Let's look at some of the problems you will encounter in maintaining trusses.

10-42. Trusses should be checked immediately after installation to locate loose bolts and bolts that are too long, too short, or too small. In some cases bolts of a smaller diameter than the drilled holes have been installed. In other cases, holes have been drilled for bolts that were never installed. In both cases you should install the correct size bolt. Where bolts are too short, the head of the bolt and the washer may have been recessed into the member. This reduces the area of the member and its weight-bearing quality. When bolts that are too long are used, it is impossible to draw the nut up tight to obtain a firm connection. Installing additional washers will take up the space and allow the bolt to be tightened correctly. Always provide support under a chord when you are making repairs that require the loosening or removal of bolts.

10-43. It is important that all truss connections be tightened periodically until the moisture content of the lumber reaches a state of equilibrium with that of the surrounding air. During the first year after construction it is necessary to tighten the bolts at frequent intervals to prevent the connections from becoming excessively loose. Loose members may result in settlement of the truss, excessive checking, and splitting.

10-44. When you perform a routine bolt-tightening operation, check the bolts to determine whether or not there is sufficient thread to draw the nut up tight. Also check the diameter of washers; if they are so small that the truss members cannot be drawn together without embedding the washer, they should be replaced with larger ones. Where it is impractical to remove the bolt to replace the washer under the bolthead, a square slotted washer may be inserted between the existing washer and the wood. Drive a nail by the washer to prevent it from turning and sliding off the bolt. The washers should be at least ¼ inch thick and not less than 2 inches square. When tightening nuts, strike the bolthead a sharp blow with a hammer to force the bolt through the truss member and break any adhesion between the bolt and member resulting from corrosive action.

10-45. In many structures, inspection may reveal that bolt tightening, because of shrinkage of the members, is required. As a general rule, bolt tightening should be done if the average takeup on bolts is more than two turns. This, of course, depends on the size of the members and the length and size of bolts. However, the importance of keeping bolts tight cannot be overemphasized. Design values are predicated upon tight connections, and the full strength of the truss cannot be realized unless the bolts are kept tight.

10-46. You will be repairing trusses by installing splices and clamps, so let's have a closer look at truss framing and methods of making repairs. Figure 108 shows a truss with a broken lower chord and the recommended method of making the repair. To make a repair of this type you will need ½- and ¾-inch bolts, washers, and wood stock. The wood splice plates should be of good quality, straight grain material and of the same size as the original chord. Use this method of repair only when the chord is 2 or more inches thick. To make the repair, you need to drill a small hole ahead of the end of the split to help prevent its becoming longer. The repair is made by adding two splice plates, one on either side of the lower chord, with the outside plate carried through the joint nearest the fracture. The reason for extending this splice plate beyond the nearest joint (of webs and chord) is that there is insufficient space on this side of the break to develop the full strength of the member when the splices are bolted in place. Apply a clamp or clamps of sufficient size to draw the broken parts of the member together and drill a hole for the ½-inch diameter stitch bolt. Install the stitch bolt with washers and draw it up tight. Also, place stitch bolts near the ends of the pieces you are going to use for splice plates. Install the splice and bolt it in place. Bolts should be set at least 7 inches from the ends of the splice and at least 6 inches apart from the length of the splice. Use a sufficient number of bolts to carry the load normally supported by the defective lower chord. Figure 109 shows the minimum spacing of bolts in lumber. This minimum spacing must be maintained to prevent weakening the member.

10-47. Bolts of ¾- or 1-inch diameter are used to bolt the splices in place because of their

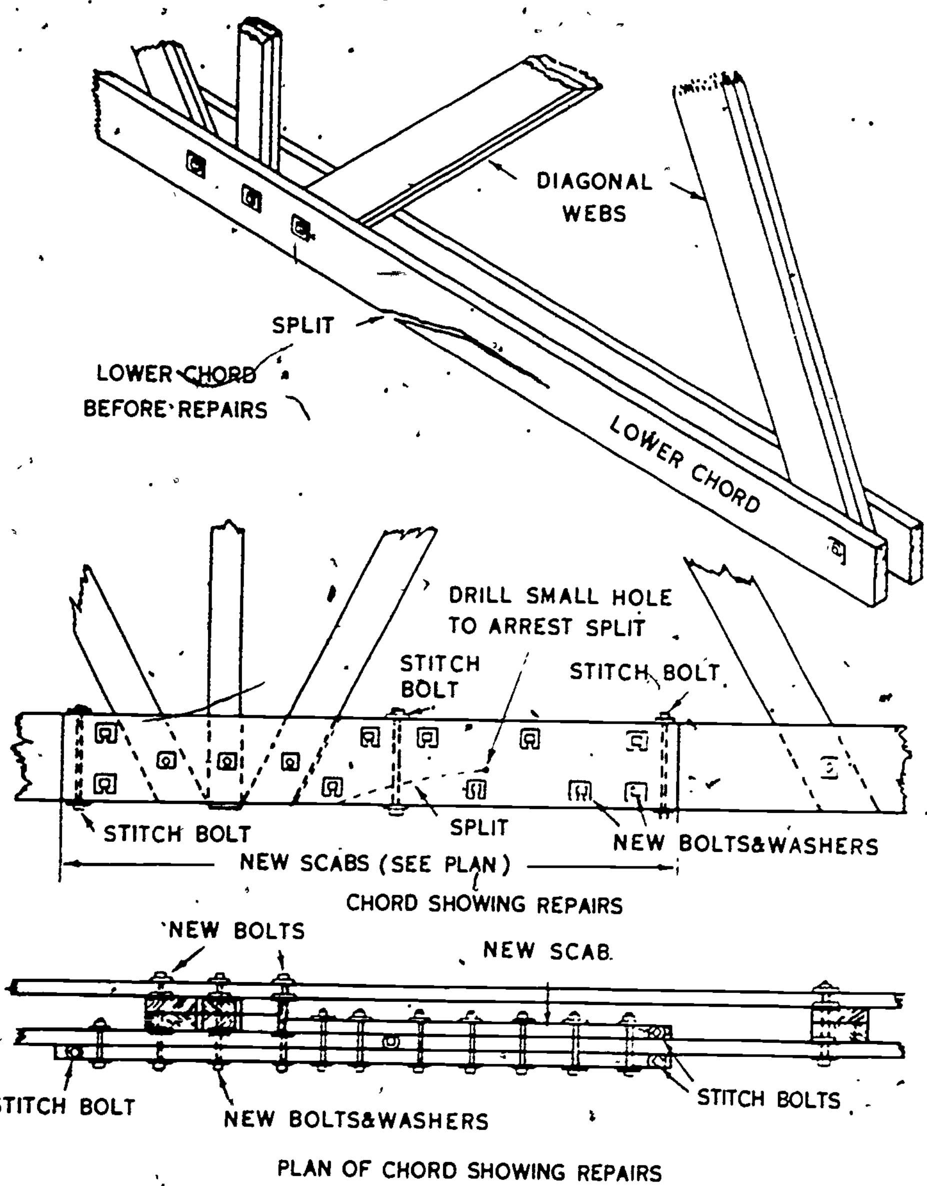



Figure 108. Truss repair.

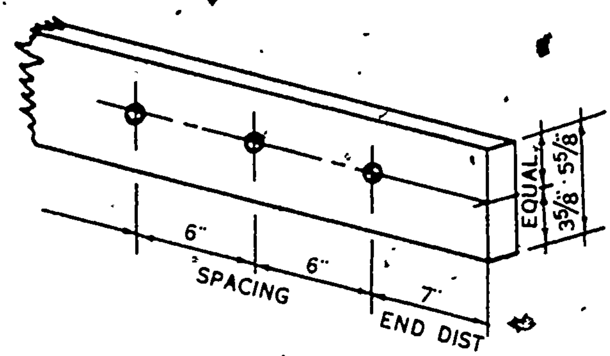
strength and resistance to shearing off between members when the load is applied. As an example, a ¾-inch bolt, placed through the two splices, and a 2⅝-inch chord could be expected to support as much as 1,980 pounds. When the chord or center member of the splice is 5½ inches thick, the ¾-inch bolt will carry as much as 3,210 pounds. These examples apply only when the wood is straight grained and well seasoned and the bolts are drawn tight.

10-48. Stitch bolts are not used in chords or webs that are less than 2 inches in thickness. Place steel plates on each edge of a thin member and fasten them with bolts that extend along the sides of the wood. A clamp of this type may also be used to fasten two or more members together.

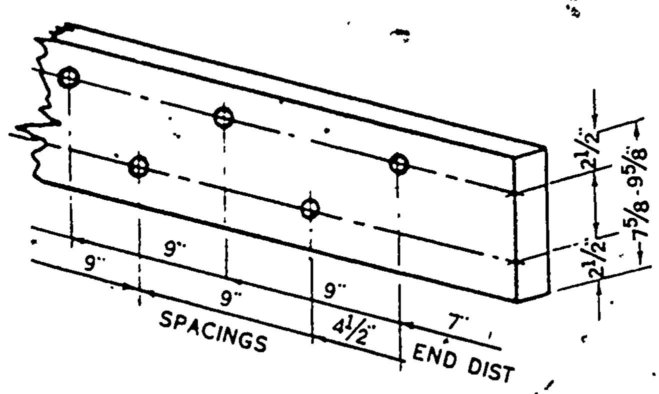
10-49. The methods used to repair trusses are also used on girders, beams, columns, and other heavy parts of frame structures.

10-50. Now that you know of the problems that you will find in the roof framing, you are ready to get to the biggest problem in the roof, the covering.

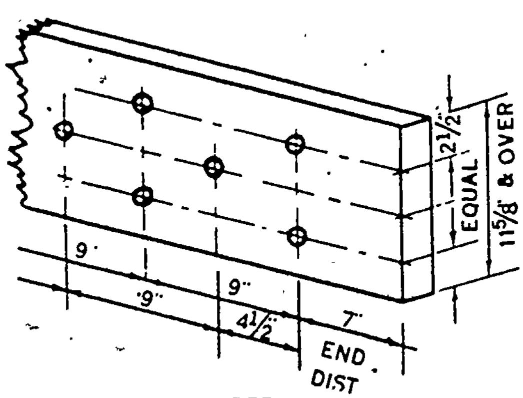
10-51. *Repairing roll roofing.* Most buildings of a temporary or semipermanent construction will have asphalt composition rolled roofing. The intended use of such structures when built was from 1 to 4 years. These buildings will receive



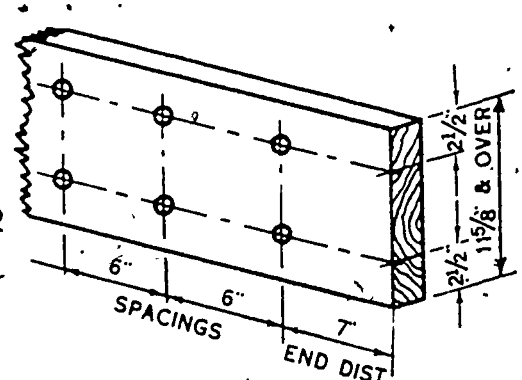

SINGLE ROW FOR 4" TO 6" MEMBERS




TWO ROWS STAGGERED FOR 8" TO 10" MEMBER




3 ROWS STAGGERED




2 ROWS IN LINE

FOR MEMBERS 12" AND OVER

Figure 109, Minimum spacing for bolts in lumber.

211

only the minimum amount of maintenance or repair that will keep them leakproof.

10-52. Small breaks and enlarged nail holes may be repaired by applying asphalt plastic cement. Small damaged areas and tears are repaired by placing a new piece of roofing below the damaged area. This is done by opening the seam directly below the damaged area and inserting the new material. The repair material should be large enough to extend 6 inches beyond the edges of the break, and the lower edge should be flush with the horizontal exposed edge of the cover sheet. Before inserting the repair strip, coat it liberally with lap cement (bitumen) where it will come into contact with the cover sheet. After inserting the strip, press down the edges of the damaged area and nail securely with nails spaced approximately 2 inches apart and about ¾ inch from the edges. Apply lap cement to the horizontal seam, press down firmly, and renail as the original seam was nailed.

10-53. When a considerable area of a roof has been damaged but the main area remains intact, repairs can be made by removing the roofing from the damaged area and applying new roofing of the same type. Full-width strips should be applied in the same manner as the original roofing.

10-54. After all other necessary repairs have been completed, repair of leaky seams should be made. Such leaks occur most frequently as a result of loose nails and fishmouths, and inadequate lapping, nailing, or cementing. Permanent repairs to leaky seams of roll roofing are made by using a membrane such as cotton fabric or lightweight, smooth surface roll roofing. Cement it over the seam and coat it with a bituminous compound.

10-55. Figure 110 shows the accepted methods of repairing various defects found in roll roofing. If reroofing is necessary, the roof deck must be restored to as nearly a new condition as possible. The existing roof covering must be removed, and all protruding nails must either be pulled or driven flush. Sheathing that is sound should be renailed when necessary, and all rotted or warped sheathing boards should be replaced with new decking. All cracks, knotholes, and resinous areas should be covered with sheet metal.

10-56. *Repairing asphalt shingles.* Asphalt shingle roofs that are correctly applied usually require no special maintenance or repair treatments. Shingles normally last for several years with little change in appearance. The first indication of normal weathering is the loss of mineral surfacing granules, slight at first, but accelerating as the loss of granules exposes more of the asphalt coating.

10-57. No definite period can be ascribed for the various phases of weathering, because they will vary with direction of exposure, the climate, and the slope of the roof. Weathering is more rapid in hot, humid climates, on south

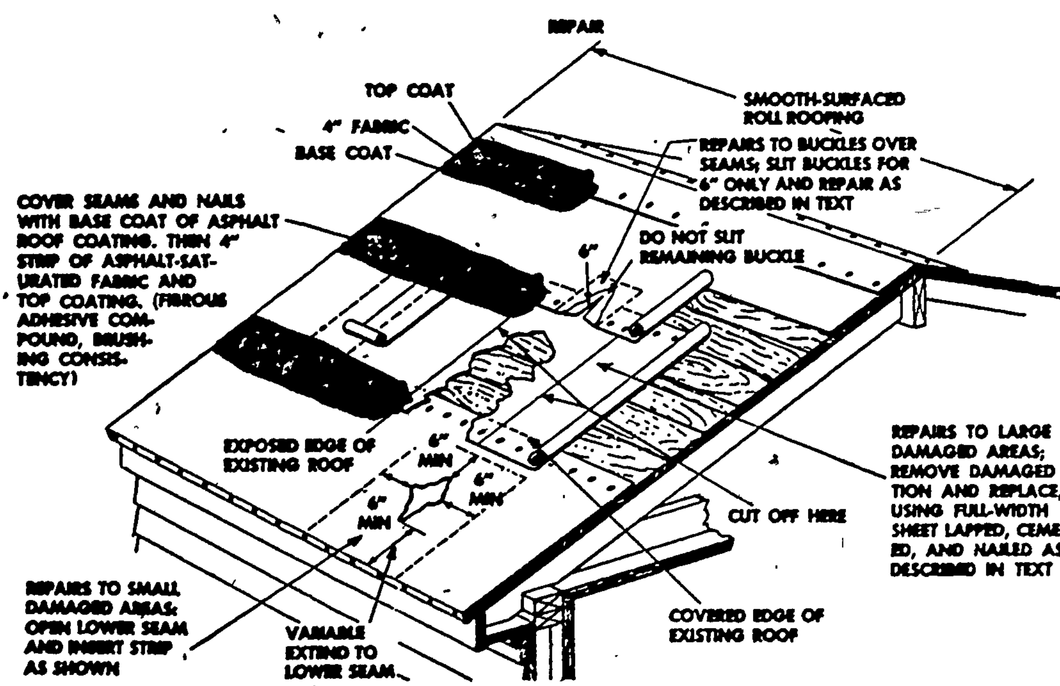



Figure 110. Repairing roll roofing.

and west exposures, and on low-pitched roofs.

10-58. On asphalt shingle roofs no sharp distinction can be drawn between maintenance and repair work. Recoating, which is maintenance for built-up roofs, is not recommended for asphalt shingles.

10-59. Repair is often required on asphalt shingle roofs that have been damaged by wind or hail. Strong wind will lift the tabs of shingles that are not stuck down with cement. The tab will break between the cutouts, or it will tear out between the nails. If you notice the turned-up tab before it breaks, you can stick it down and avoid more extensive repairs.

10-60. If the tab blows off, you will need to replace it with a new shingle. When a single tab blows off, you can replace it with a single 12- x 12-inch section of a three-tab strip shingle. There is no need to replace the entire shingle. Pull the nails from both sides of the old tab and in the course above so that you can insert a new piece. Work carefully to avoid breaking the shingle in the course above. Old shingles are brittle and are easily broken. Reach under the course above and carefully cut off the broken shingle to form a straight cut from the center of the cutout to the top edge of the shingle. A linoleum knife with a hook-shaped tip works best for this type of cutting. Insert the new section of shingle and nail it in place. Renail the course above and apply a spot of bitumen under the loose tabs.

10-61. When you have extensive wind damage or frequent repairs of the type mentioned in the preceding paragraph, you need a tool (nail ripper) that is adapted for the job. This tool looks like a double-headed tack hammer with a flat steel handle. The head is ½ inch square and extends about 1½ inches on each side of the handle. The handle is actually a nail puller. It is bent slightly to form a pry surface, and the end has a V-cut similar to the claws on a hammer. Each side of the V is tapered to the end of the handle so that it works as a wedge when it is driven under a nailhead. You can use this tool in a close area without damaging the shingles in the course above. The double head is of soft metal, and you can strike it with your good hammer without damaging the face of the hammer. Start the roofing nail by sticking it into the shingle, place one head of the tool on the nailhead, and strike the other with a hammer. By using this method you can drive nails without damaging turned-up tabs when you swing the hammer.

10-62. Asphalt shingle roofs that are damaged by hail fall into two categories: those with major damage and those with minor damage. Major damage occurs when hail breaks both layers of shingles and allows water to enter the building. If the roof is old and brittle, the tabs may break off and blow away or slide off the building. When this type of damage is extensive, you will have to install a new roof to assure a good covering. Minor damage occurs when the hail knocks the granules off the tabs to expose black spots of felt but does not break the shingle. This damage shortens the life of the covering but will not cause the roof to leak. Cover the spots where the granules are removed with a coating of plastic cement to protect the shingle and help to reduce weathering. This is not the neat, workmanlike job we want it to be, but it will protect the roof for at least a part of its normal life expectancy. The idea is to keep water out of the building.

10-63. Use care while working on a roof. The shingle roof with a 3- or 4-inch slope may not be slippery to stand on, but it usually gets that way with age and loosening of the granules. It presents about the same type of problem as trying to stand on a pile of marbles. Use the ladder or chicken board, shown in figure 111, or a lifeline to walk on roofs having more than a 3-inch slope. Also use the board or ladder to protect brittle roofs (such as slate, tile, or asbestos-cement) and mineral surfaced

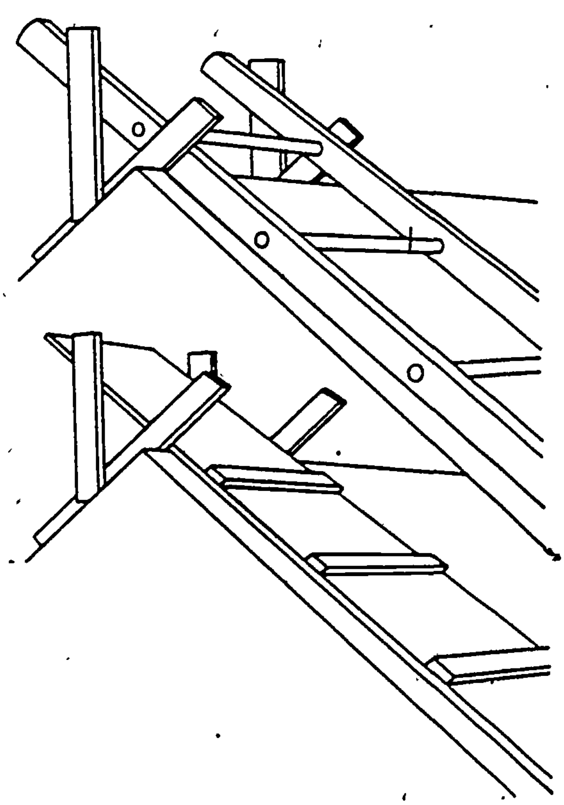


Figure 111. Ladders.

built-up roofs. Many old roofs are harmed more by foot traffic than by weathering.

10-64. *Repairing built-up roofs.* Make careful plans before repairing a built-up roof. The entire roof should be inspected and all defects noted. Asphalt and asphalt-saturated felt should always be used in the maintenance of asphalt built-up roofs. and coal tar pitch and coal tar saturated felts must be used in the maintenance of cool tar pitch roofs. Asphalt and coal tar pitch are not compatible, and contact between the two should be avoided. When inspecting the roof prior to repair, disregard small blisters and buckles in the membrane. Blisters or buckles, though large in area, will not leak as long as they are intact. Blisters or buckles. over which the felts have cracked or disintegrated, must be repaired to prevent leaking. To repair, scrape off all surfacing material down to a dry felt surface in an area which extends 2½ feet beyond the edge of the blister or buckle. Make an X-cut through the blister or buckle with the ends of the cut extending 12 inches beyond the edges. Fold back the four corners of the membrane and allow to stand until thoroughly dry. Apply a liberal mopping of hot bitumen and press the corners of the membrane firmly into the hot bitumen. Over this, apply at least two additional layers of 15-pound saturated felt mopped on with hot bitumen and extended at least 18 inches beyond the ends of the cuts. If the original roof was smooth surfaced, finish the repair by pouring a surface coating of hot bitumen at the rate of 20 to 25 pounds per square. On mineral surfaced roofs, recoat the area with hot bitumen, poured on at a rate of 70 pounds per square. While the bitumen is still hot, embed gravel at the rate of 400 pounds per square. or slag at the rate or 300 pounds per square, over the repaired area.

10-65. Whenever the bituminous coating or the felts become exposed on a mineral surfaced roof, the area should be repaired to prevent weathering of the exposed area. Brush or sweep the loose slag or gravel from the area. Cover with hot bitumen poured at a rate of 70 pounds per square and embed fresh gravel or slag. Old gravel or slag may be reapplied when the dust and dirt have been screened from it. Never attempt to apply hot bitumen over old slag or gravel surfacing because it will not adhere. When the original roof is of asphalt bitumen, the old felts must be covered with a thin coat of asphalt primer before the new bituminous coating is poured. The primer should be brushed on and allowed to thoroughly dry. Coal tar pitch roofs need no primer, but the area to be repaired must be clean. Both asphalt and coal tar pitch are hardened and embrittled by overheating and consequently are rendered more susceptible to changes in temperature. Overheating the bitumen can therefore reduce the useful life of the built-up roof. Heating kettles are equipped with thermometers to help you keep a close check on the temperature.

10-66. *Repairing metal roofing.* Galvanized steel roofs need not be painted immediately upon exposure. In fact, without special treatment or the use of special paints, it is better to postpone painting of galvanized steel for several months to assure adhesion of the paint. Painting may be postponed until a bright yellow corrosion product appears on the zinc coating. This corrosion indicates that the zinc coating no longer protects the base metal. However, it is much safer to paint before the appearance of this product, and subsequent regular maintenance painting will prolong the service of the roof.

10-67. Inadequate laps in galvanized steel roofings may be repaired by calking the seams or, in severe cases where calking is impracticable, by stripping the laps with a fabric and bituminous membrane. With any method, workmanship is extremely important. It should be realized, also, that repairs of this kind cannot be expected to last as long as the galvanized sheets; they will require maintenance treatment and probable renewal at intervals. The best method of repairing breaks in galvanized steel roofing is to replace the defective sheet of roofing with a new one.

10-68. *Repairing asbestos roofing.* Major causes of damage to this type of roofing are hail, foot traffic, contact with tree limbs. warped roof decks, and failure of fasteners. When only a few shingles or corrugated sheets are broken, they should be removed and new ones applied. When a large percentage (25 percent or more) are broken, they should be removed, and a new roof applied. The age and condition of undamaged units should determine whether you salvage them for use in the new roof.

10-69. When an asbestos-cement roof fails because of the fasteners, the failure is usually a general one, and attempts to replace each individual fastener are futile. When such failure occurs, normally on a very old roof, it is best to remove the entire roof covering. Whether the old roofing can be reapplied depends upon the age and condition of the material. Normally, if the roof can be removed without damage, it may be reapplied to form a lasting roof.

10-70. To replace a broken shingle, you will need the nail-ripping tool we discussed in the repair of asphalt strip shingles. Shatter the broken shingle so that it can be easily removed, and then use the nail ripper to cut or draw the nails. Clean the area of all chips and install a new shingle. When it is impossible to cut or remove the old nails, you must cut notches in the new shingle so that it will fit in the normal position. Fasten the shingle in place by nailing in the joint in the course above. Cut a piece of copper, galvanized iron, or painted tin about 3 inches wide and 6 inches long. Place the metal over the joint where you drove the nail and slide it under the course above so that about 4 inches of it extends down over the joint and covers the nailhead.

10-71. Broken asbestos-cement corrugated sheets will be replaced with new sheets and fastened in place in the same manner as the original sheets. When you cannot use the same method of fastening, you may substitute toggle bolts with lead or plastic washers. Make a hole in a ridge that will allow the bolt to pass through easily. Allow plenty of clearance for the bolt. Insert the bolt and draw it tight enough to seal the bolthole with the washer.

10-72. *Repairing slate roofing.* If only a few slate shingles are broken, they should be removed and new ones applied. If more than 25 percent of the shingles are broken, the entire roof should be removed and a new roof applied. The age and condition of the undamaged slates should determine whether you can salvage them for reuse in a new roof.

10-73. No definite criteria can be given for determining whether a slate can be reused. However, generally speaking, a slate may be reused when the exposed surface is not faded appreciably, the slate shows no evidence of disintegration, and the slate gives a sound "ring" when it is held as lightly as possible between thumb and finger by one corner and struck a sharp blow by the knuckles.

10-74. In replacing a broken slate, you should remove all pieces and cut the nails with a ripper. Insert a new slate of the same color and size as the broken one and nail it through the vertical joint of the next course above. Drive the nail about 2 inches below the butt in the second course above. Force a 3- x 6-inch piece of copper under the second course above so that it will lap the joint and cover the head of the new nail, as shown in figure 112.

10-75. *Repairing tile roofing.* The most frequent repair work on a promenade tile roof is that caused by using too few expansion joints between the promenade tiles or by permitting the expansion joints to become filled with solids. The tiles are laid in a 1-inch-thick bed of cement mortar made with 1 part cement to 3 parts sand. The joints should be $3/16$ to $1/4$ inch wide and filled flush with a cement mortar made of

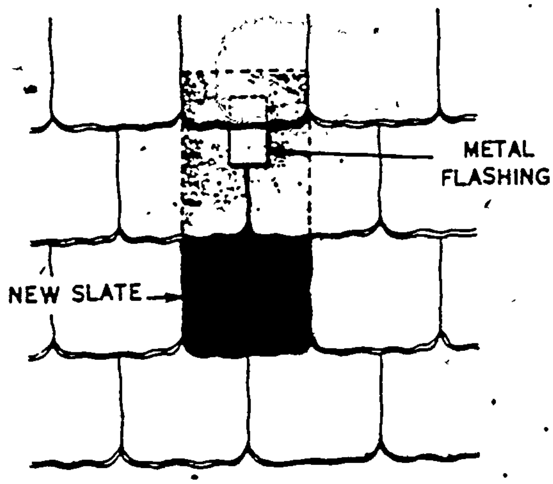



Figure 112. Installing a new slate.

1 part cement and 2 parts sand. Expansion joints, $3/4$ inch wide and filled with a flexible joint-sealing compound, should be provided on 10-foot centers and at all vertical surfaces. Expansion joints should extend from the top of the tile through the 1-inch bed of cement mortar to the bituminous membrane. The membrane is a built-up roof of asphalt or coal tar, usually 5 ply, with a final mopping of 25 pounds of asphalt or coal tar instead of the usual heavy pouring of bitumen specified for roof surfaces with slag or gravel.

10-76. The type of damage and the repair of sloping tile roofs are essentially the same as for slate roofs, the exception being that on occasions and after long periods of service, tile roofs in otherwise satisfactory condition may leak because of the disintegration of the 30-pound felt underlayment.

10-77. On sloping roofs, broken shingle tiles will be replaced with new ones by the same method we discussed for slate and asbestos-cement shingles. Spanish tiles are replaced by troweling portland cement mortar on the new tile surface that will be lapped by the course above and on the surface that will lap the tile in the course below. Fasten the new tile in place with copper wire. Interlocking tiles use special fastening clips or nails that are easily removed. Slip out the old tile and install a new one. Representative shapes of roofing tiles are shown in figure 113. Thickness, dimensions, and weight of these tiles vary with each manufacturer, and no attempt will be made to identify them here.

10-78. Now that you have a good understanding of the procedures for installing and maintaining roof covering materials, we need to discuss the accessories used with roofs. These accessories include flashing, gutters, and downspouts.

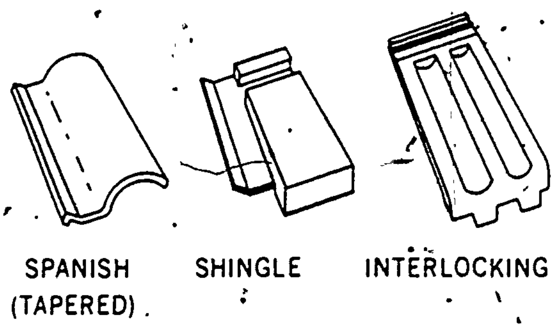



Figure 113. Roofing tiles.

10-79. **Flashings.** The purpose of flashing is to make a roof watertight at an angle intersection (the valley of intersecting roofs), or where a sloping surface joins a vertical surface (around a chimney), or at the edge of a roof where it joins the sidewall.

10-80. *Types of flashings*. When two sloping roofs intersect, a valley is formed, and some type of flashing must be used. A hasty valley flashing, satisfactory for temporary buildings, is made of two thicknesses of rolled roofing. One piece should be approximately 22 inches wide, and the other piece about 14 inches wide, as illustrated in figure 114. A valley flashing of sheetmetal, however, is recommended on permanent buildings. The sheetmetal must be at least 14 inches wide and placed over deadening felt (tar paper). The roofing material should be cut 3 or 4 inches from the centerline of the valley to provide adequate space for water drainage.

10-81. In order to form a watertight joint (where a sloping roof meets a vertical wall), you should use sheetmetal or rolled roofing flashing. Rolled roofing is recommended only for temporary types of construction. The method of application is similar with both materials. The lower edge of the flashing must fit over the top of the material below, and the top edge must be covered by the roof covering or exterior sidewall so that water cannot run under the flashing, as illustrated in figure 115.

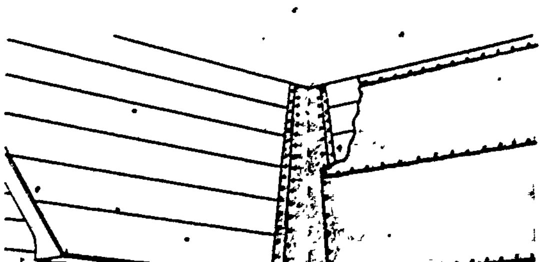


Figure 114. Valley flashing with rolled roofing.

10-82. A roof jack (or vent stack flashing as it is commonly called) is used to shed water around pipes that extend through the roof. It is formed of 4-pound sheet lead to fit around vent stacks and extends 8 inches in all directions from the joint made by the stack and roof surface. The top of the lead flashing is turned over and into the top of the stack, as shown in figure 116. When this is not done, water will enter between the stack and flashing. If the stack is too tall for the flashing to reach the top, the flashing must extend at least 6 inches up the stack, and be covered with some type of counterflashing or rain guard that will prevent water from running down the sides of the stack.

10-83. A metal eave flashing is used to protect the lower edge of the decking on all except flat roofs. A formed strip of galvanized metal is installed to shed rainwater away from the edge of the board. This flashing can be formed in the metal shop, or you can get commercial types

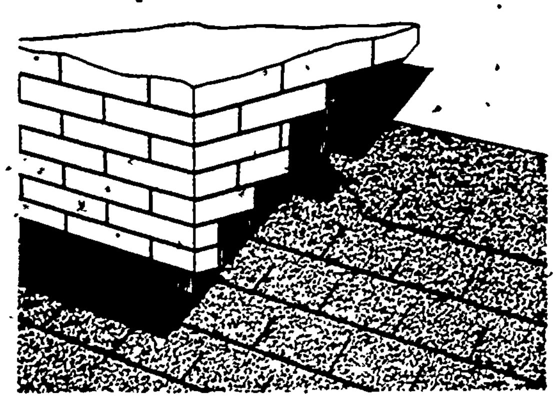


Figure 115. Vertical wall flashing.

similar to those shown in figure 117. Those flashings shown as A and B in figure 117 can be used along the eaves and gable ends of shingle roofs. The flashing shown as C in figure 117 is designed for pitched built-up roofs having a gravel or slag surface.

10-84. These flashings protect the edges of a roof and are used in conjunction with required starter courses and edge strips of composition materials. They are not a substitute for any part of the roof covering.

10-85. *Materials for flashings*. Materials used for flashings must resist weathering for long periods of time. These materials should outlast the roofing and in most cases remain effective for the life of the building. It is not uncommon to replace a roof without removing the original flashings. Some flashings break or pull loose because of movement of the framework and will need replacing. Others, made of soft metal, will take much abuse without causing you a bit of

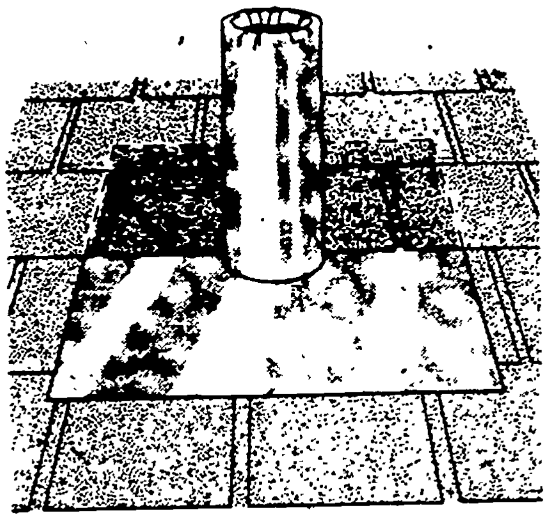


Figure 116. Vent stack flashing.

work. Metal flashings are usually required with slate, tile, asbestos cement, metal, wood shingle roofs, and masonry parapet walls. The principal materials are copper, tinplate, lead alloy, galvanized iron, hard lead, and aluminum.

10-86. Copper flashings, correctly installed, require little repair. Sixteen-ounce soft copper is satisfactory under most conditions, but hard copper is best for preformed flashings. Twenty-ounce copper is recommended for long runs subjected to extreme temperature variations. Copper will stain exterior wall surfaces if it is not painted. Copper flashings should be painted with a bituminous compound when it is subjected to the actions of soft coal smoke, sulphur dioxide, or sodium chloride fumes.

10-87. Lead alloy (terne or terneplate) is sheet iron or steel coated with an alloy of approximately 4 parts lead to 1 part tin. This metal sheet must be painted on the back side before it is installed to protect it from condensation.

10-88. Hard lead is an alloy of lead and antimony (a hardener). It is highly resistant to most fumes. It expands easily but is brittle and will wrinkle or "creep" when it is used in large sheets. It should be painted when it is used in contact with concrete or lime mortar.

10-89. Lead sheets are produced in various thicknesses, widths, and lengths. Ordinarily lead sheets are referred to by the number of pounds per square foot when they measure less than 1 inch in thickness. Most of the sheets you will need are thin enough to be stored in rolls. Lead sheet is especially useful in making flashings for the vent stacks of the plumbing system.

10-90. Aluminum compares favorably with copper as a flashing. It will last indefinitely, but you must paint it to prevent corrosion when it is exposed to concrete or mortar.

10-91. Steel sheets are used for roofing, siding, and other flatwork. The sheets may be either flat (smooth surface), corrugated, or formed into ribbed and flat areas. A zinc coating of a specified thickness is applied to the metal by either the hot-dip or the electrolytic method. The following types and classes are available.

- Type I, flat.
- Type II, corrugated.
- Class A, extra heavily zinc-coated (0.0306-inch nominal thickness and thicker sheets only).
- Class B, heavily zinc-coated.
- Class C, moderately heavily zinc-coated.
- Class D, ordinarily zinc-coated (commercial).
- Class E, lightly zinc-coated for severe forming (light commercial coating).

10-92. Type I, class C sheets in a nominal thickness of 0.0545 inch (2.280 pounds per square foot) to 0.0150 inch (0.625 pounds per square foot) will bend without breaking the zinc coating.

10-93. Type I, class D and E sheets in a nominal thickness of 0.0672 inch (2.812 pounds

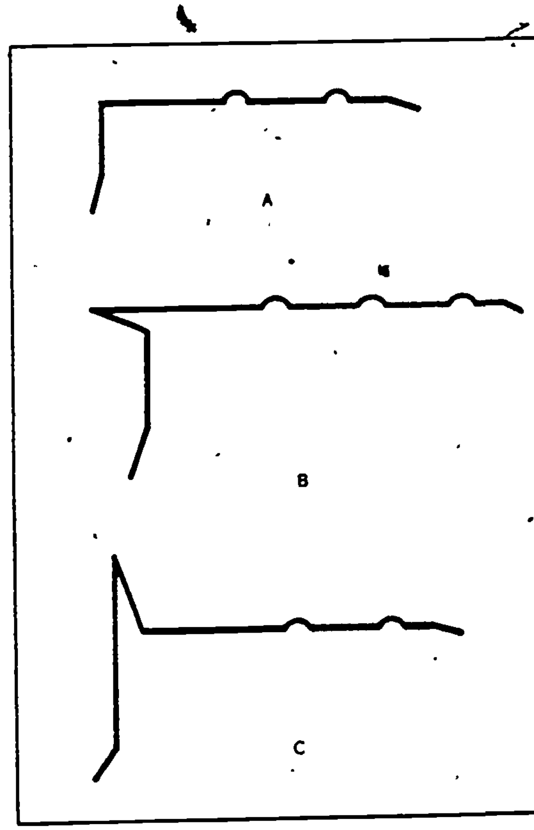



Figure 117. Eave flashings.

217

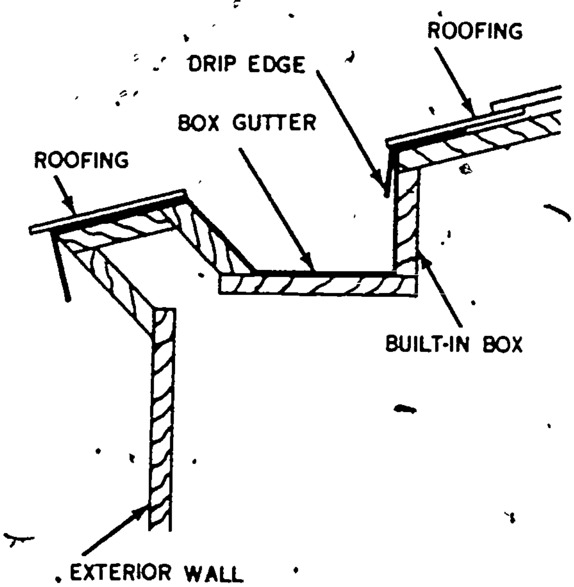



Figure 118. Box gutter.

per square foot) to 0.0150 inch (0.625 pounds per square foot) will bend without flaking the coating.

10-94. Each zinc-coated sheet is marked with the class (A, B, C, D, or E) and the nominal decimal thickness. The type is visually identified as flat or corrugated. The gage thickness of the galvanized sheet is based on the United States standard gage. Order galvanized sheets by nominal thickness in inches.

10-95. A composition or membrane flashing is commonly used around the edges of flat roofs surfaced with built-up roofing. The roofing felts are laid up the cant strip and at least 4 inches on the vertical surface that has been prepared with a cold-troweled-asphalt mastic cement. Each layer of composition material must be mopped with hot mastic. Generally it is best to cap the membrane with a metal counterflashing secured with metal wedges and sealed with an elastic compound. Bituminous material also serves as an inexpensive, though inferior, substitute for metal flashings on top of masonry walls

10-96. After you solve the problems on the surface of the roof, then comes the problem of collecting and carrying the water away from the building. The first part of this system is the gutter, so let's look at it before we get off the roof and put away the ladders.

10-97. **Gutters.** A gutter is a trough designed to catch water at the eave of a building and carry the water to a downspout. There are many different types of gutters in use, ranging from the box gutter, which is built into the design of the building, to the formed metal gutters that hang below the eave.

10-98. *Box gutter.* A box gutter is built of wood and lined with a waterproof material. Modern methods require a durable metal lining, such as copper or aluminum. One form of box gutter is shown in figure 118. This form of box gutter is built within the framework of the roof and cannot be seen from the gound. The box gutter is wide and shallow and is sloped from one end to the other. When a stoppage occurs at the outlet, water will spill over the low side of the gutter and the purpose of the gutter is defeated. Repairs to stop a leak consist of placing a lining or bitumen and cotton fabric membrane inside the gutter.

10-99. *Formed gutter.* Gutters formed from galvanized metal or aluminum are often referred as hanging gutters. The half-round type shown in figure 119 is available in 3- through 12-inch widths. Hangers are used to hang it in position just below the eave. The hangers clip over rolled lips on the side of the gutter or form a band around it. The upper end of the hanger extends over the eave and is nailed in place under a shingle. You may find places where gutters (or additional hangers) were installed after the

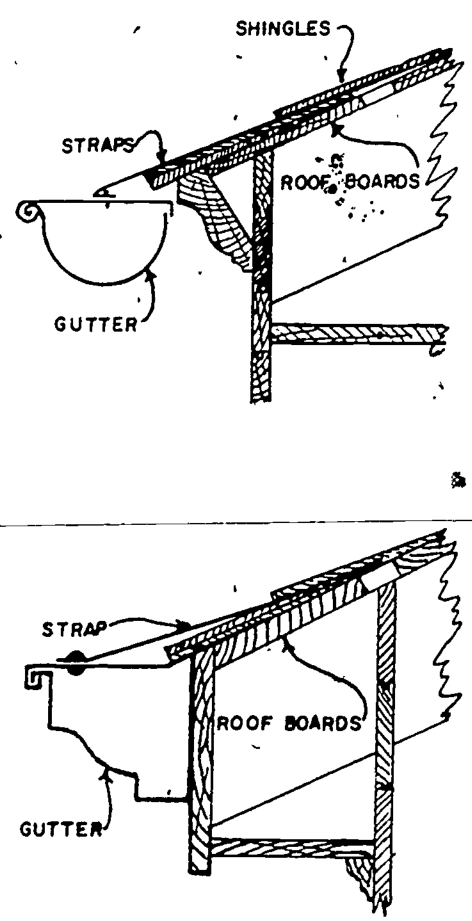



Figure 119. Half-round and formed gutters.



117

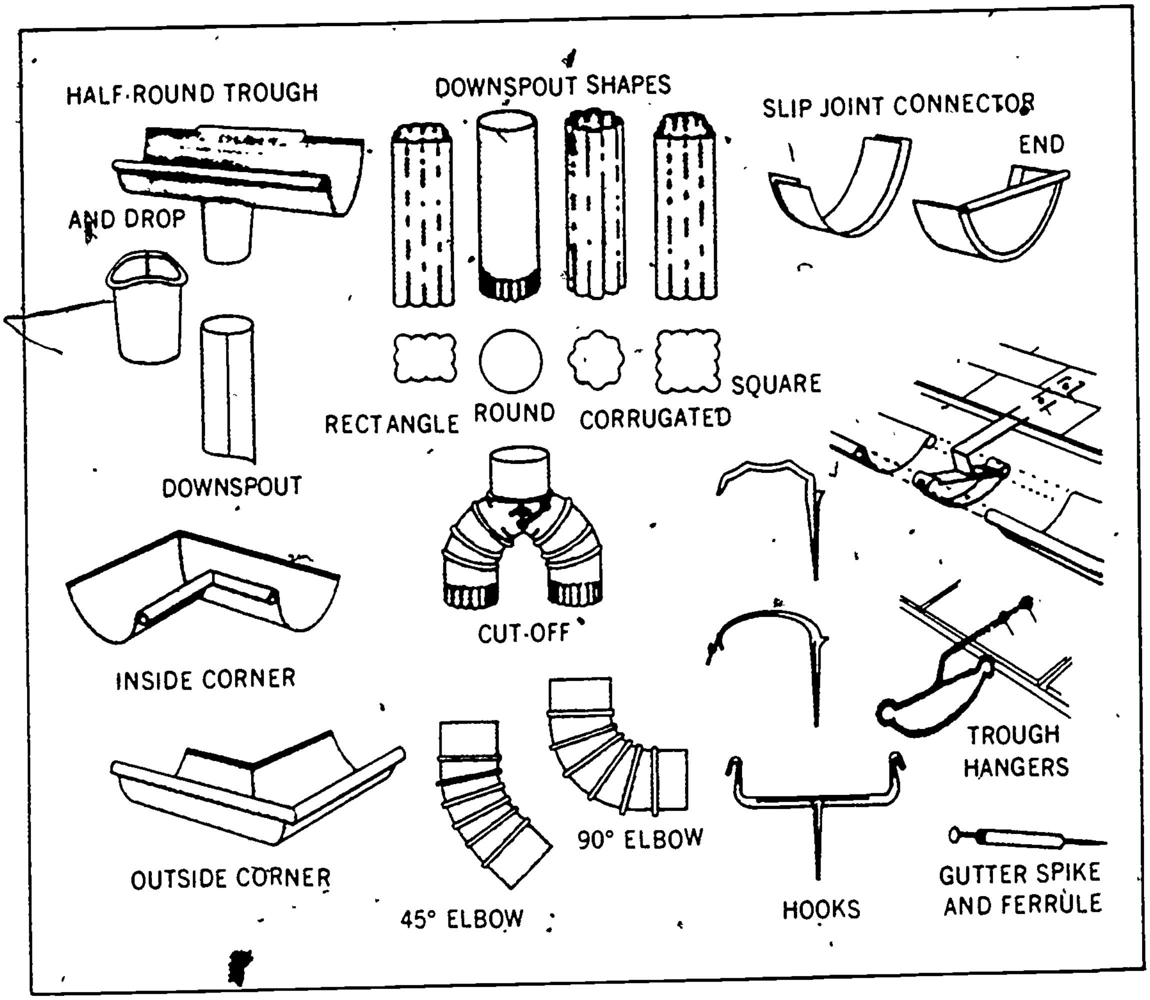



Figure 120 Gutters and downspouts.

shingles were placed and the hanger was fastened on top of the shingles. This is a common cause of leaks and should be eliminated.

10-100. Another formed metal gutter is referred to as a box gutter because of its shape. This gutter is also shown in figure 119. It is made of galvanized metal or aluminum and is fastened in place just below the eave.

10-101. Figure 120 illustrates the main parts of a roof drainage system. The half-round gutter is shown, along with round, corrugated, square, and rectangular downspouts. Inside and outside corners and slip joint connectors are used to connect lengths of gutter into one continuous trough. Trough hangers are fastened to the roof and form a cradle for the gutter. The downspouts are held to the exterior wall with hooks, straps, or wire. Elbow and cutoff joints are used to form the route of the downspout.

10-102. **Downspouts.** The purpose of the downspout is to carry rainwater from a gutter to ground level and direct the water away from the foundation of the building. One or more downspouts are required on each gutter (or connected gutters), depending on the amount of water collected by the gutter. Additional downspouts may be installed by cutting a hole in the bottom of the gutter and soldering a drop in it. The shape and size of the drop must fit into the downspout you intend to use. Connect the downspout to the drop with two sheet metal screws. This joint may be soldered on some permanent buildings, but it is not always a good idea. The drop does not support the downspout. Hooks, straps, or wire are used to fasten and support the downspout. Sheet metal screws placed in the slip joints of the downspout prevent excessive movement of the individual joints when the metal expands and contracts.

10-103. The routing of the downspout can be changed from the vertical position by using 45° or 90° elbows. The elbows have slip joints that fit over the lower end of a downspout and inside the upper end of a lower downspout.

219

CHAPTER 4

# Interior Framing

HAVE YOU EVER entered a building where the inside finish was so eye-catching that you stopped and took another look? If you have, you have experienced one of the results of good workmanship. The importance of good workmanship in interior finishing of a building cannot be overemphasized. The workmanship of the entire building reflects how well you have done the interior. If the inside finish is unprofessional in appearance, the chances are that the hidden framing follows the same pattern.

2. The interior of a building will require more time to finish than the exterior. It also requires more skill and patience, but by taking your time you can do a job that you can be proud of.

3. The interior finish includes wall, ceiling, and floor coverings, as well as the trim members for doors and windows. Other interior finish work includes the adding of baseboards and the installing of cabinets, cupboards, and stairs. Miscellaneous interior finish includes picture molding, chair rails, door and window stops, and any other trim members called for in the drawings and building specifications.

## 11. Interior Walls and Ceilings

11-1. The framing of interior walls and partitions is very similar to the framing of exterior walls as discussed in Chapter 2 of this volume. In this section we will discuss the framing, insulation, coverage, and trim of the walls and ceilings.

11-2. **Walls.** An interior wall or a partition wall is used to separate sections of a building. It may be a weight-bearing or non-weight-bearing wall, depending on the way the ceiling joists are placed. Most partition walls with a wood frame are made of standard 2 x 4's. However, walls that contain the vent stack (plumbing vent) may be constructed of 2 x 8's or 2 x 10's, depending on the diameter of the pipe used in the vent stack. Double plates are used on both ends of the studs to provide an easily accessible nailing surface for the ends of wall panels. The studding in weight-bearing walls usually has the same spacing as the exterior walls in the same building (12 or 16 inches on center). Non-weight-bearing walls may have studs spaced 24 inches on center with single studs and headers at door openings. Block bridging is not usually required, but is sometimes used for the purpose of fastening the top edge of a wainscot (protective panel on the lower 3 or 4 feet of wall).

11-3. While we are still on the subject of framing, let's look at the insulating materials that are placed within the framework.

11-4. **Insulation of Walls and Ceilings.** Buildings of light frame construction should be well insulated to insure comfort in warm weather as well as cold. The insulating of the average frame structure in cooler climates is usually justified; the saving of fuel in 3 to 5 years will more than pay for the insulating cost.

11-5. Heat is lost from a building in two ways: by air leaking around doors and windows and by conduction of heat through the materials in the walls, floors, and ceilings, which then radiate heat to the outside air. These two losses should not be confused because both can occur at the same time on the same door, window, wall, or floor. The methods of insulating against them, however, are entirely different. The proper fitting of doors and windows will decrease air leakage around them. Regardless of the fit, doors and windows should both be fitted with proven weather stripping. Air leakage through walls may be serious in a poorly constructed building. It can be almost entirely eliminated in frame construction by properly applying good building paper beneath the outside wall covering. The second way of losing heat from a building is by transmission through solid (airtight) material. For example, when a glass of hot water is held in the hand, the heat of the water is transmitted through the glass and can be felt. The heat from a warm interior escapes to the cooler air outside by transmission through the window glass in this same manner. Heat is also lost by transmission through the wood of doors and walls, and through the plaster. Insulating materials must be poor conductors of heat so that when placed in the walls they will form a thermal barrier. This barrier tends to keep the building more comfortable in both summer and winter by slowing the transmission of heat.

11-6. Insulation materials are divided into four general types: flexible, rigid, fill, and reflective. The flexible, rigid, and fill types are made up of small cells (dead air spaces). These small, dead air spaces slow the transmission of heat; and the thicker the material is, the more effective it becomes in resisting the passage of heat.

11-7. *Flexible insulation.* Flexible insulation is made in the form of quilts or batts which fit between standard spaced studs, as shown in figure 121. Quilts are normally used for insulating the walls because the insulating material is entirely inclosed with a protective covering and the possibility of settling is eliminated. Most quilts have a continuous tab on each edge for fastening them to the frame members. Tacks may be used for fastening the quilts in place but an automatic stapling gun makes an easier and quicker job of it. Quilts are installed between the studs after the outside sheathing is in place. They are packaged in rolls and can be cut to the correct length with either a knife or a pair of tin snips. Quilts may be filled with any one of several different types of insulating materials, the most common of which is spun glass. When working with any insulating material, care should be taken to avoid splinters from handling with bare hands. Protective equipment and clothing should be worn to eliminate hazards.

11-8. Insulating batts are similar to quilts except that they are packaged in flat batts, 48 inches long and wide enough to fit between standard spaced frame members. One side is usually covered with a waterproof paper but the other side has either plain kraft paper or no covering at all. They are often used in the attic between the joists for insulating the ceiling. They can also be installed between floor joists for insulating over the crawl space in buildings without basements. In the attic, the need for fastening is eliminated because the batts lie flat. The same type of material is used for making both batts and quilts.

11-9. *Rigid insulation.* Rigid insulation boards are made in flat sheets from ½ to 2 inches thick. They may be made of cork, wood pulp, corn stalks, and various other vegetable fibers. Cork is not generally used for insulation in construction work except in special temperature-control rooms, such as walk-in refrigerators. Most present-day rigid fiberboards not only provide insulation but also serve as a structural sheathing in place of wood. The rigid boards most commonly used for sheathing are treated with asphalt to make them waterproof. This treatment may be either a complete saturation or a thin exterior coating. When untreated rigid boards are used for sheathing, waterproof building paper should be used the same as for wood sheathing. Rigid boards may have square edges, shiplapped edges, tongue-and-groove edges, or a combination of these. When

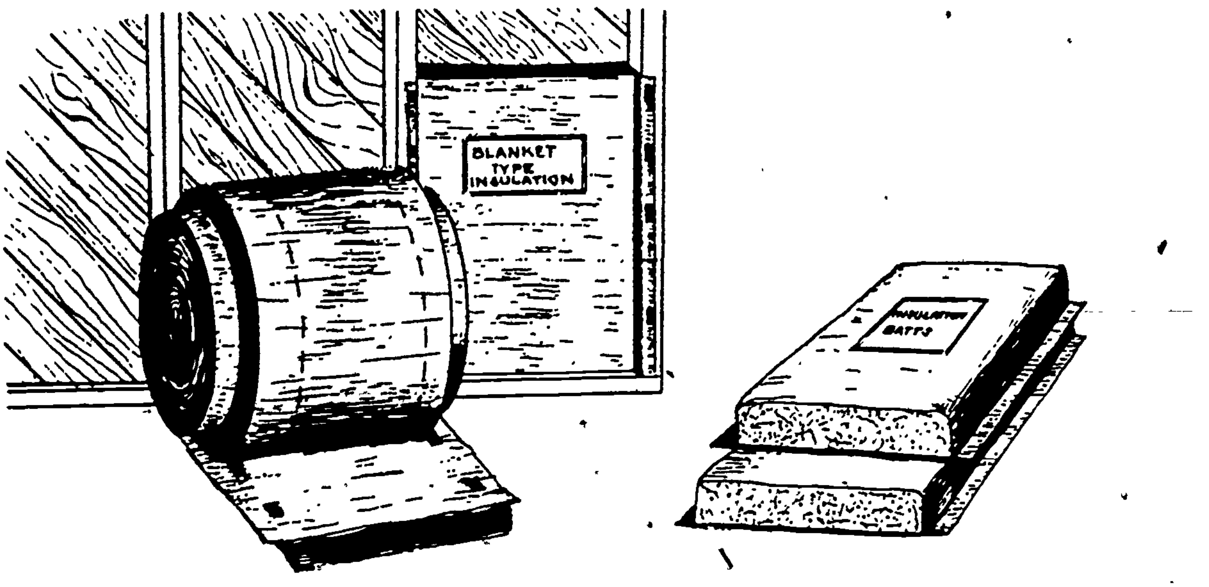



Figure 121. Flexible insulation.

fiberboard sheathing is to be covered with shingles, furring strips are recommended, since the fiberboard does not provide solid anchorage for ordinary nails. Furring strips or horizontal siding must be nailed through the sheathing into the studs.

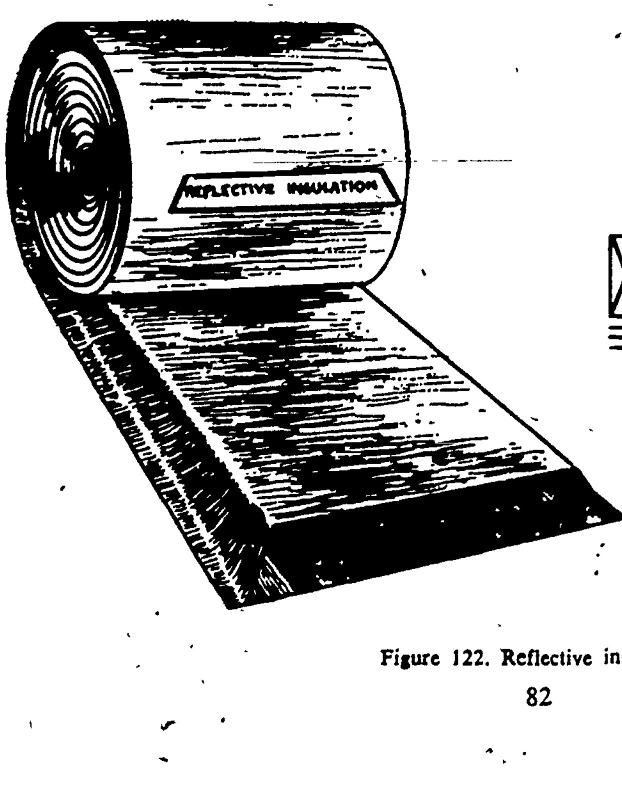
11-10. *Loose fill insulation.* Loose fill insulation is the same material as that used in quilts or batts. It is packaged in large bags and may be used for insulating both the ceiling and side walls of a building. When using it in the attic, it is a simple matter to fill the space between the joists. For the outside walls, however, the loose insulation must be blown in through an opening made near the top of the wall between each stud. After a building has been completed, it is almost impossible to install quilt or batt type insulation without excessive labor, and damage to the walls; but loose fill type insulation can be installed in finished walls with little difficulty.

11-11. *Reflective insulation.* Reflective insulation turns back radiant heat similar to the way in which a mirror reflects light. Since very little of the heat penetrates the reflecting surface, this type of insulation is very thin, usually aluminum foil, cemented to one or both sides of a craft paper. It can be used separately or in conjunction with the other three types we just discussed. When used separately, it is looped between the studs, tacked or stapled on the edge of each stud, and creased, as shown in figure 122. This method creates an additional air space, which also adds to the insulating effect. Ordinarily the shiny side of the foil should face toward the inside on walls and toward the outside when placed between the rafters in the roof. Thin foil may also be cemented to one or both sides of rigid fiberboards or it may be used as part of the protective covering on quilts or batts.

11-12. **Interior Wall and Ceiling Covering.** The finish of interior walls and ceilings adds to both the insulating and decorative characteristics of a building and often adds strength as well. Special types of covering also improve the acoustic (sound absorption) properties of a room.

11-13. *Dry wall.* The introduction of a variety of dry, rigid wallboards has greatly reduced the use of lath and plaster in present-day construction. These wallboards are made in sheets of various materials such as vegetable fibers, plaster, or plywood. Wallboard sheets are made in standard sizes 4 feet wide and from 6 to 12 feet long. They may be obtained in other sizes for special jobs. Although dry walls are not generally considered to be as strong as wet walls, they are less expensive and easier to install. The sheets are put directly on the studs or joists without requiring lath. Many of the dry wallboards are made of specially finished surfaces which eliminate the need for any further treatment.

11-14. Fiberboard wall coverings are made of cork, wood pulp, corn stalks, and various vegetable fibers, and are made in sheets from ½ to 2 inches thick. When used for covering interior walls, these sheets have a decorative



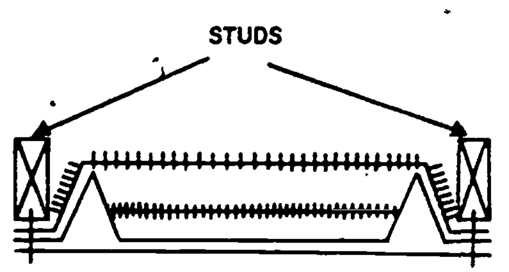




Figure 122. Reflective insulation.

finish on one side. For a neat appearance, the joints between the sheets may be covered with batten strips of either wood or fiberboard. When fiberboard sheets must be cut, a special fiberboard knife is recommended to obtain a smooth cut. Fiberboard sheets are also made in small pieces called tiles, which are often used for covering ceilings. These tiles may be square or rectangular to fit standard stud or joist spacing. They may be made with a lap joint which permits blind nailing or stapling through the edge, or they may be of tongue-and-groove material fastened in place with 2d box nails driven through special metal clips. No nailheads are exposed with either of these two types. The edges are beveled to form a recessed V around each tile which hides the joints, and also gives a decorative effect. Since all fiberboard tiles need solid backing behind the joints, furring strips are placed at right angles across the bottom of the joists and short furring pieces are placed along the joists between the furring strips, as shown in figure 123.

11-15. To replace a single tile usually requires that the old tile be removed from the center outward by breaking the tile and removing small sections. Any other method usually results in damage to adjoining tile. The lip and back side of the groove are removed from the new tile so that it can be easily fitted into place. The new tile is either glued in place or fastened with small nails. The nails should be placed in the design of the tile so that the hole will not be conspicuous. Set the head of the nail below the surface of the tile so that it will not be seen.

11-16. Tile that is installed in metal channels is easily replaced by sliding an end tile out of the groove and working to the tile that needs replacing. This situation develops where the tile ceiling is "dropped" below the original ceiling and is suspended on wire hangers. The metal framework is not strong enough to support the tile, electrical fixtures, vents, and you. Use a ladder of sufficient height so that you can work without adding some of your weight to the ceiling. Some large (2- x 4-ft.) panels are installed in individual frames and can be removed individually.

11-17. Sheetrock wall covering is made similar to rock lath, except that it has no holes and the paper covering is thicker and stronger. The sheets are very brittle and require extremely careful handling to prevent breaking. Approximately 1¼ inches of each edge is made 1/16 inch thinner than the body of the sheet. When two sheets are placed side by side, the thin edges form a recess to receive perforated paper tape and gypsum cement which conceals

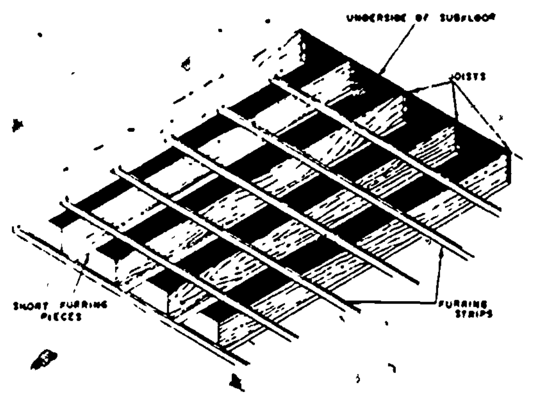



Figure 123. Furring out ceiling joists.

the joints between the sheets. A ⅛-inch space between the edges of the sheets helps to hold the filler cement in place. The sheets are usually fastened in place with blued nails which have an oversize head and are 1½ inches long. The nails along the edges are covered with the perforated tape and cement. Nails are spaced about 5 inches apart and ⅜ inch from the edge. Those in the middle of the sheets are spaced 8 or 9 inches apart and should be set below the surface to receive the filler cement. It is common practice to strike the nailheads one extra blow for setting. This makes a slight depression (hammer mark) which holds the cement around the head. When installing plasterboard, the ceiling is usually put on first.

11-18. When removing damaged plasterboard, use a method that will also help you in fitting a replacement piece. Scribe, cut, and remove a square section or one having straight sides and square corners. This will help you when it is time to cut and fit the new section. Start removal at a joint and cut across to the next stud and along it for the desired distance. After removing the damaged section, cut a 2 x 4 the length required to fit between the studs at the top (and bottom) of the repair. Nail the 2 x 4's in place, leaving one-half the thickness exposed to provide a nailing surface for the patch. A 1 x 4 or 2 x 4 nailed to the side of the one stud (the other one had the joint on it) will provide nailing surfaces for the patch and adjacent material.

11-19. The joints between plasterboard panels are filled and covered with joint compound. Perforated tape is bedded into the compound for added strength. The compound is applied in layers, with the first layer filling the joint and lapping over the edges of the panels by 2 or 3 inches. The tape is pressed into this layer and is covered by a second layer of compound. The compound is worked out to a thin edge on each side of the tape with a broad knife (wide knife similar to a scraper or wide putty knife)

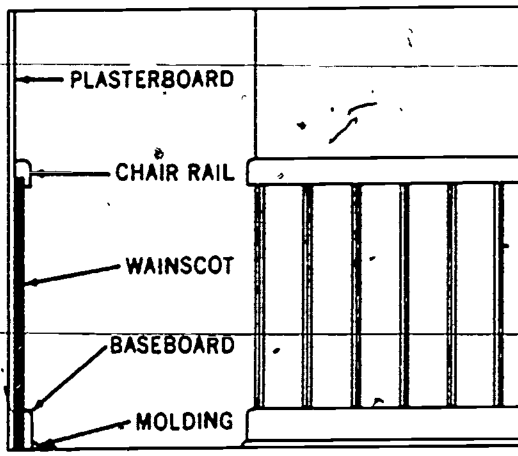



Figure 124. Wood panel wainscot.

to form a nearly flat surface that will not show when the wall is painted. This process works well on tapered edges of panels, but more and wider layers are required to cover the joints made by patches. The hammer marks (indentations) and nailheads may be covered with one or two layers of compound.

11-20. When lower sections of plasterboard walls are continuously damaged by rough usage, it may be necessary to replace the panels with plywood. Where rough usage is the main factor, the situation may be corrected by installing a wainscot, as shown in figure 124.

11-21. A wainscot is used to protect the lower section of the wall. It may be constructed of wood, plywood, or tempered (hard) fiberboard. The top edge, located 3 or 4 feet above the floor, is covered with a molding. This top molding is commonly referred to as a chair rail.

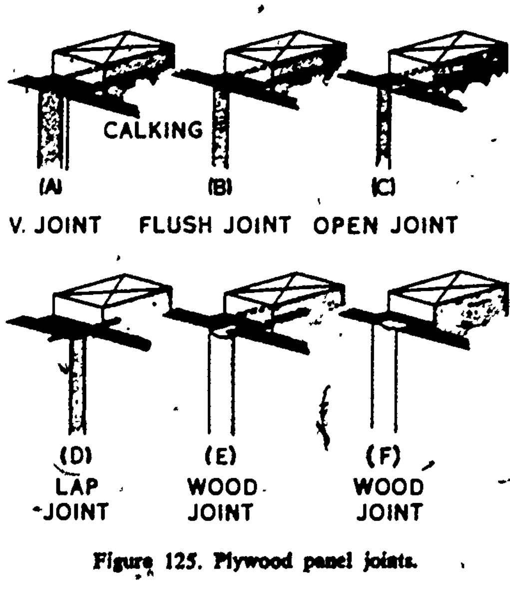



Figure 125. Plywood panel joints.

11-22. *Wood paneling.* Plywood panels are used extensively as interior wall covering and can be obtained on the market in sizes from ¼ to ¾ inch thick; 36 to 48 inches wide; and 60, 72, 84, or 96 inches long. Douglas fir is the wood most commonly used for making these large panels of plywood. However, some face panels are available in various cabinet woods, such as oak, birch, mahogany, and other hardwoods. Plywood gives a wall a wood finish surface. If desired, the less expensive plywoods can be used and covered with paint or wallpaper or can be decorated in the same way as other plastered surfaces. These panels are usually applied vertically from floor to ceiling and fastened with 4d finishing nails. Special strips or battens of either wood or metal may be used to conceal the joints when flush joints are used. Joints can also be treated with moldings, either in the form of battens fastened over the joints or applied as splines between the panels, as shown in figure 125. An outside corner of a room may be given a simple and effective treatment by finishing it with quarter-round molding, whereas a cove molding will finish an inside corner. These two finishes are illustrated in figure 126.

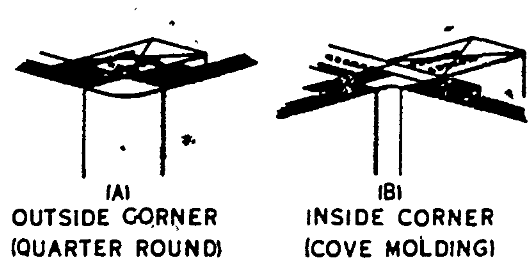



Figure 126. Plywood corners.

11-23. Wood produces an interesting wall covering, giving the effect of stability and warmth. The wood used in wall covering is usually selected because of its desirable color, the number and kinds of knots, and its grain. The edges are molded and the surface sanded to produce an appealing finish.

11-24. When wallboards are applied, headers must be placed between the studs near the top and bottom of the wall. Wood panels can be applied directly to the stud frame wall.

11-25. There are many other types of panels used on walls and ceilings but they are installed, replaced, or repaired in the same way as those in our discussion.

11-26. In building construction, the house plans usually have a section covering the details for all built-in equipment. This equipment includes closets, wardrobes, utility cabinets, work tables, and openings for heating, plumbing, and ventilating equipment. Regardless of the type of built-in equipment, a detailed plan must be used.

11-27. Before attempting to make any built-in article, study the details and organize the work in a systematic, convenient order. This simplifies the entire operation and makes the construction work much easier. After studying the plans of the article to be built, make out a bill of material listing all items to be used. When the bill of material is completed, make a full size drawing of the article (if possible). This large drawing, if used correctly, will eliminate slight errors that might be present in the scale drawing. This simplifies the problem of construction and helps determine the proper sequence for doing the job. The full size drawing can be cut out and used as a pattern when several identical pieces of equipment are to be made.

11-28. **Interior Trim.** The various trim members used in finishing the interior of a building are the casings around the doors and windows; the baseboard, with base and shoe mold; picture mold; chair rail; cornice mold; and panel mold. There should be a definite architectural relationship in the design of all these members to that of the doors, windows, and the general architecture of the building. Many varieties of wood, such as birch, oak, mahogany, walnut, chestnut, and white and yellow pine are used for interior trim. When the trim is to be painted, a close grain wood is desirable, since it provides a better painting surface.

11-29. The base trim member which is fitted against the wall on top of the finished floor is known as the base. It is usually made up of two members, the baseboard and the base shoe, as shown in figure 127. Frequently, a third member is added. It is called the base cap molding and fits on top of the baseboard. These members are nailed with 6d finishing nails.

11-30. The picture mold shown in (A), figure 128, is placed against the wall near the ceiling, usually up against the ceiling. Some builders prefer to lower it to 12 or 16 inches below the ceiling. The cornice mold shown at

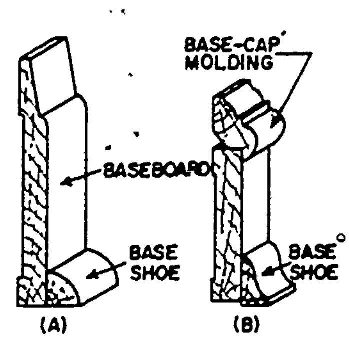



Figure 127. Baseboard and shoe mold.

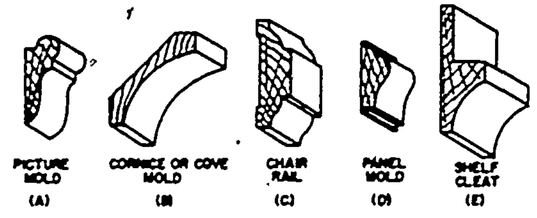



Figure 128. Trim members.

(B) is usually fitted and nailed against both the ceiling and wall of a room. The chair rail (C) may be placed on the wall at any one of various heights, such as the height of the back of a chair or 48 inches from the floor. The panel mold (D) is used to divide wall spaces into panels. Shelves in closets rest on cleats, illustrated at (E), making it easy to remove the shelves as desired.

## 12. Interior Doors and Window Trim

12-1. Installation of interior doors and window trim is an important part of the inside finish of a building. Likewise, the maintenance of these items is also important. Timely maintenance will reduce repair and replacement work on these items.

12-2. **Interior Doors.** There are many different stock designs of doors available on the market today, enough to fill all the needs of the average builder.

12-3. Paneled doors are probably the most common type used in light-frame construction. They are made up of stiles (vertical members), rails (crossmembers), panels, and moldings for holding the panels in place. The number and shape of the panels may vary considerably, as was shown in Chapter 2 of this volume. Because the panels are inset in the stiles and rails, they can be changed from wood to glass with little difficulty.

12-4. Flush doors, although relatively new on the market, are perhaps the most desirable for present-day construction. They are, however, slightly more expensive than other types. These doors may have either a solid core built up of softwood or a hollow core made up of girds (plywood strips), as previously shown in Chapter 2 of this volume. The core in either type usually has stiles and rails similar to those of a panel door. Plywood is laid over the core to provide a smooth surface on each side. The edges of these doors are covered with the same type of wood as the surfaces. Although the hollow core doors have the same appearance as solid core doors,

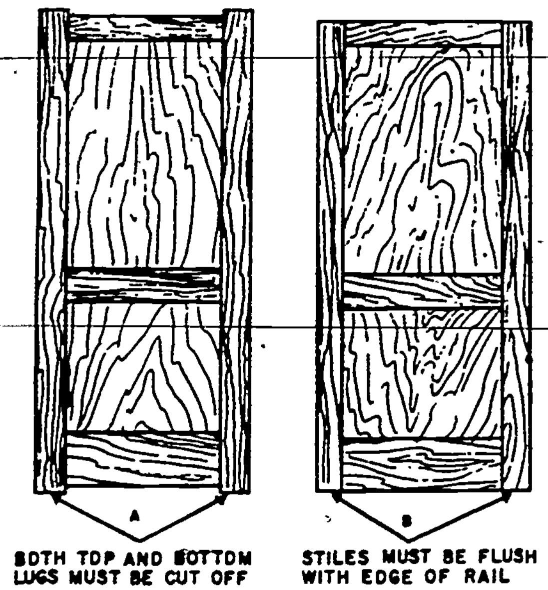



Figure 129. Lugs on paneled doors.

they are lighter in weight and are more effective for soundproofing and heat insulation.

12-5. *Fitting of doors.* Regardless of how carefully you install door jambs, they must be fitted to the opening where they are to be used. The reasons for this are that the doors may be slightly wider than the specified size and the ends of the stiles (lugs) on unhung paneled doors project beyond the edge of the rails, as shown in figure 129. The lugs provide protection from damage before the door is hung. On paneled doors, the edge on which the hinges are mounted is known as the hinge stile, and the other edge the lock stile. You should select the stile with the straightest grain for the lock, especially if a mortise lock is to be used. On exterior doors which have outside faces, the direction of the swing determines the hinge stile and lock stile.

12-6. Before you start to fit the door into the opening, the lugs on paneled doors must be cut off even with the rails, as shown in figure 129. If the door will not fit under the head jamb, the bottom edge may require trimming. If more than 1 inch must be trimmed off, it should be taken equally from both top and bottom. When a threshold is to be used, the door should be cut 1/8 inch shorter than the vertical distance between the threshold and the head jamb. This allows 1/16 inch for clearance at both the top and bottom of the door. If no threshold is to be used, the space at the bottom of the door should be sufficient to clear the thickness of a rug (usually 1/2 inch).

12-7. When the door is cut to the correct height, it should be positioned in the opening, as shown in figure 130. With the door in this position, a line scribed on the lock edge, 1/8 inch from the lock jamb, will mark the width of the door. A jack plane can be used to trim the door.

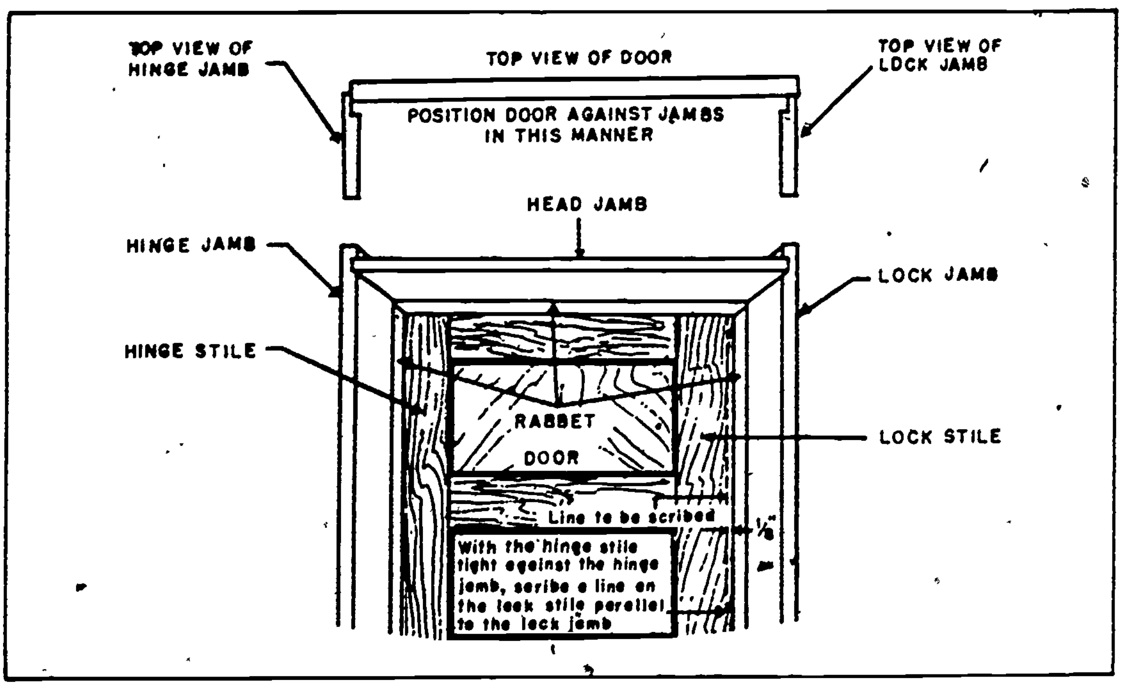



Figure 130. Positioning door in opening.

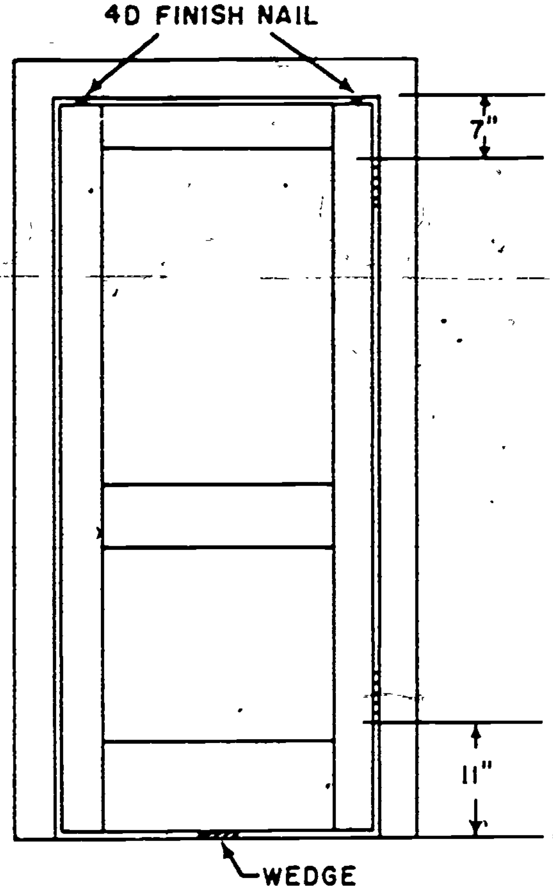



Figure 131. Wedging door.

12-8. When the door has been fitted to this opening and is ready for the hardware, it should be positioned and wedged in the opening. An easy way to maintain the spacing at the top is to place two fourpenny finishing nails between the head jamb and top rail. This is shown in figure 131. A single wedge near the center of the bottom rail will hold the door in place. The nails on the top rail will allow the door to be shifted if necessary. When the door is properly positioned, it should be firmly wedged and the hinge locations marked on both the stile and the jamb 7 inches from top of door and 11 inches from bottom of the door. The hinges used on most passage doors require a mortise (gain) for at least one of the hinge leaves, as shown in figure 132, and with some hinges both leaves must be mortised. The mortise must be carefully laid out and chiseled so that the hinge fits perfectly. An incorrect hinge mortise may prevent the door from closing and cause the door to swing improperly.

12-9. *Installing locks*. The design of locks is probably even more varied than the design of hinges. However, certain information relative to locating and mounting is common to most lock designs. When the hinge installation is complete and the door is in place, the layout for the lock can be made. Because of the great variety of locks, the layout will depend upon the specific lock to be installed. The one governing factor concerning the location of door locks is the height of the spindle knob above the floor. This height is usually 36 inches. The instructions inclosed in the package with the lock give special information and specifications concerning the size and location of holes necessary for proper and easy installation.

12-10. Figure 133 illustrates a tubular lock and guide tool. This special guide tool is made for locating and boring the holes when installing a tubular lock. This tool locates the center points for the spindle holes and acts as a guide for the bit when boring the level hole in the lock stile. This guide tool fits all standard door thicknesses and, when properly used, makes the barrel hole level and correctly located in relation to the spindle hole.

12-11. **Inspection and Maintenance of Doors.** Many things can happen to doors that will cause them to fail. Decay, resulting from exposure to the weather, or the shrinkage of door members may cause distortion or failure. If the joints become loose or the lock stile sags, the door will drag or bind. A thorough inspection is necessary to determine effective remedies for failing doors. The following list will give you a good start on making a checklist that applies to doors on your base:

- Examine opening to see that hinge and lock side of jamb are parallel.
- Check header to see that it is level.
- Check anchorage of jamb.
- Check anchorage of hinges and other hardware.
- Check lock face plates for projection beyond stile (along the bevel).
- Check all members for swelling, shrinking, and warping.

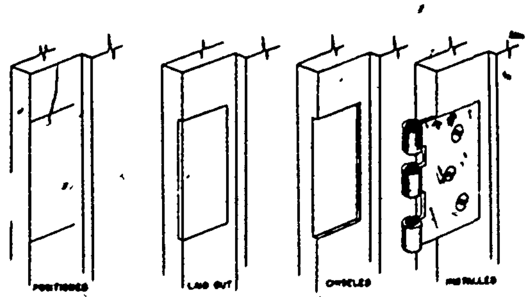


Figure 132. Setting hinges.

12-12. When a door shrinks, remove the hinge leaves and install a filler (cardboard or metal shim) underneath. This filler forces the door closer to the jamb at the lock edge, and provided hinge pins do not bend, the door should then operate satisfactorily.

12-13. Doors or door members may require rebuilding because of neglect or abuse. Remove the door to a flat surface and replace damaged member. Carpenter's bar clamps assist in holding door members square while you drive nails or screws.

12-14. A warped door which has sprung inward or outward at the hinge edge is impossible to close without applying pressure against the bulging part. This trouble is generally overcome by placing an additional hinge midway between the other two to hold the door straight. If another hinge cannot be obtained, temporary repair is made by shifting the hinges outward on the door jamb.

12-15. Settling of the foundation may cause the door frame to spread apart, thus widening the doorway. As a result, the bolt in the lock may not reach the strike plate, making it impossible to lock the door securely. Insert thick cardboard strips beneath the leaves of the hinge attached to the jamb. This shifts the door toward the lock side. Another method, more complicated, but one which produces better results,

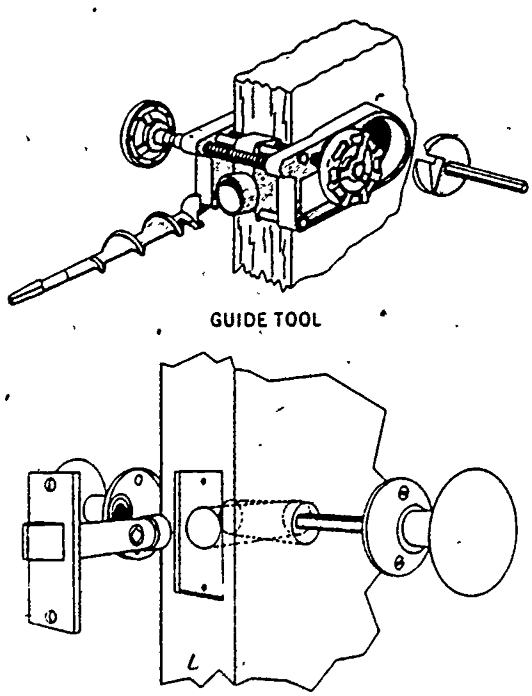



Figure 133. Tubular lock and guide tool.

is to lift off the striker plate and glue and nail or screw a wood strip extending up and down the entire length of the door jamb. It is necessary to cut a hole in this strip for the latch bolt. An alternate method is to remove the hinges from the door and screw a full-length wood strip to the door. Countersink all nails or screws and putty over all holes.

12-16. When the latch does not operate because of poor alinement with the striker plate, enlarge the hole in the striker plate by filing. If the bolt strikes squarely on the plate and requires removal of as much as ⅛ inch of metal, remove the striker plate and raise or lower it to match the height of the bolt.

12-17. The door is trimmed only as a last resort. However, do not cut doors immediately following rain or damp weather. When dry, the door may fit too loosely.

12-18. The failures in panel doors may be due to loose members. This causes binding at the hinge edge and friction between the lock and strike plate.

12-19. Trouble with locking apparatus is generally caused by defective knobs or locks. Check the knob to determine whether it is loose on the spindle. Where a lock does not move smoothly, replacement may be necessary, although repairing worn parts or lubricating with graphite frequently overcomes the difficulty.

12-20. An excess of space between door and stop causes the door to rattle. Removal and refitting of stop while the door is closed remedies this difficulty. The door may also rattle because of too much play between the latch and strike plate. Correct this condition by moving the strike plate toward the stop.

12-21. Hinges become loosened if a door is too tight on the hinge edge and binds against the hinge jamb. If such a door has plenty of clearance on the lock side and the entire pin seems to move slightly when the door is closed, loosen the hinges at the frame and insert cardboard under the outer edges. To make a uniform space between the jamb and the door on a sagging door, insert a strip of cardboard under the inner edge of the top hinge in the leaf which is fastened to the jamb, as shown in figure 134. This usually corrects the trouble, since it pulls the upper part of the door closer to the jamb. Excessive space above the door and along the outside (lock edge) may be corrected by loosening the screws in the leaf of the bottom hinge, which is attached to the jamb, and inserting cardboard under the outer edge.

12-22. Broken panels in panel doors are usually replaced with a piece of exterior grade plywood. You may want to modify some panel

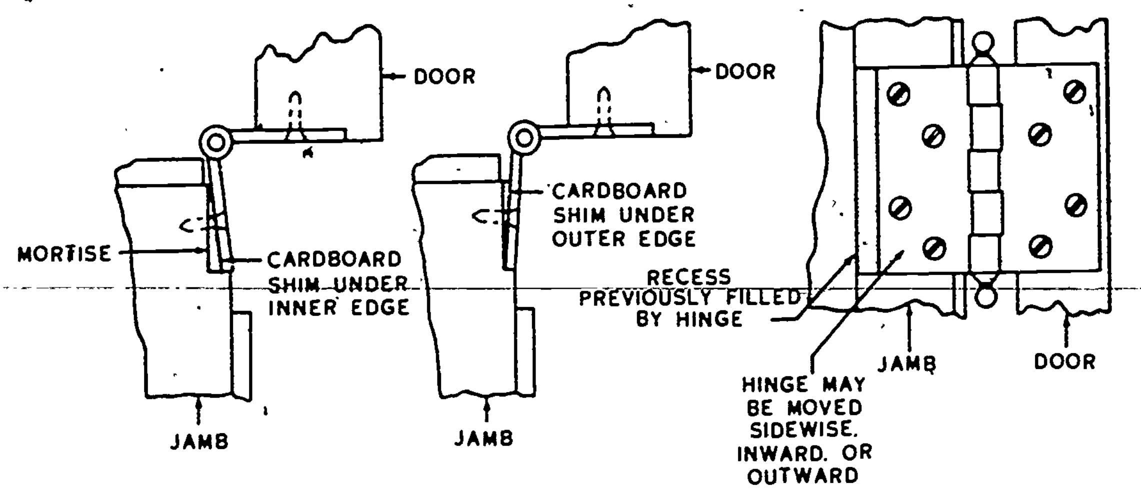



Figure 134. Hinge adjustments for binding doors.

doors by removing a panel and installing louvers, hardware cloth, or glass. You can use a wood chisel to remove the molding around the panel. Cut a piece of plywood 3/16 or 1/4 inch thick and 1/8 inch undersize in width and length to replace the old panel. Use quarter-round molding to replace the old molding and hold the new panel in place. The panel is not glued or nailed in place. Fastening the panel to the door will cause the door or panel to split when shrinkage and expansion cycles occur. You may use glass to replace a wood panel. Remove the molding and panel, and install the glass with glazier points and putty or quarter-round molding. Use a bed of putty to prevent water from getting in the rabbet behind the glass.

12-23. **Interior Window Trim.** Windows have many of the same maintenance requirements as your interior and exterior doors. The installation and maintenance of windows have been covered in Chapter 2 of this volume, except for the installation of the interior trim or casing, sill stool, and apron. Double-hung windows will have the interior trim or casing fastened to the head jamb and to the two side jambs with the appropriate size of finishing nails, depending upon the type and thickness of the interior trim or casing used. The apron and sill stool are fastened in position as shown in figure 135. Figure 135 also shows where the interior trim or casing is positioned in relationship to the other parts of the window.

12-24. Casement windows usually will have a sill stool and an apron installed without any interior trim or casing. The wall covering material is continued around the window jamb until it is up against the casement sash frame.

12-25. Your maintenance of the interior trim or casing, sill stool, and apron will consist of replacement of the necessary parts to put the window in a serviceable condition. Now that we are finished with the walls, ceiling, trim, doors, and windows, we are ready to study about floors and their maintenance.

## 13. Finished Floors

13-1. The finished floor is the wearing surface placed over the subfloor. If there is no subfloor, it is placed over the floor joists. In Chapter 2 we discussed sills, joists, girders, and bridging sufficiently to establish their location and purpose for our use in this section.

13-2. **Wood Floors.** Wood used for the finished floor should always be well seasoned, because nonseasoned lumber will shrink and leave openings between the flooring strips. Flooring, except for beech, birch, or maple, is sawed from

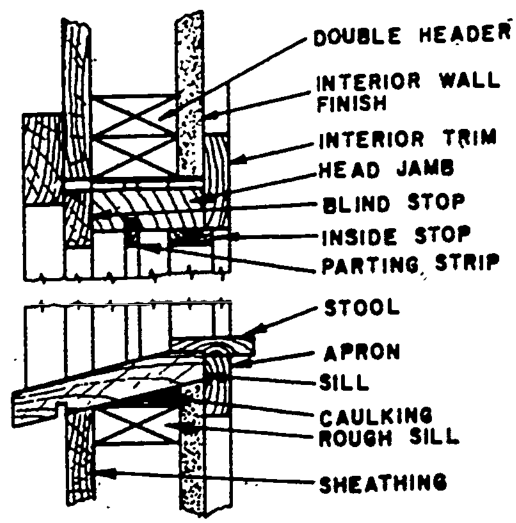



Figure 135. Head jamb and sill section.

229

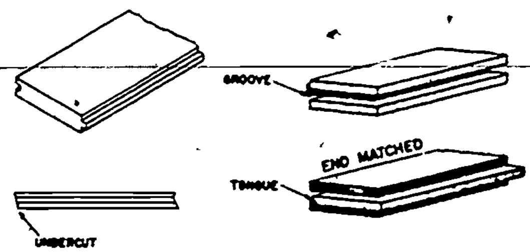



Figure 136. Undercutting flooring.

a log in two ways either as quarter-sawed (edge-grain) or as plain-sawed (flat-grain). Remember that you learned this in Volume 1 of this course. Flat-grain softwood flooring is not recommended for permanent structures, although it may be used occasionally in temporary buildings where paint is applied for a finish. Because edge-grain lumber has greater wearing qualities, it is best for floors that will receive abnormal amounts of wear. Regardless of whether flat-grain or edge-grain lumber is used, some of the pieces will have a more vertical grain than others. These pieces should be specially selected and used in doorways or other areas of excess traffic because of their greater resistance to wear.

13-3. Finish flooring laid on a subfloor may be either hardwood or softwood, depending upon the use of the building and the cost of flooring. Oak flooring usually is considered the most desirable hardwood for finish flooring in residential-type buildings. It is available in both red and white oak, either quarter-sawed or plain-sawed.

13-4. Maple, although usually more expensive than oak, is more desirable for use in roller skating rinks and similar places because it probably will stand more rough usage than any other type of wood floor.

13-5. Softwoods used for flooring are divided into two grades: select and common. The "A" and "B and Better" select grades are used when the floor is to be stained, varnished, or waxed, whereas the "C" and "D" select grades are used for floors to be heavily stained or painted.

13-6. Before starting to lay the finish flooring, the subfloor must be thoroughly swept to remove all scrap material. Heavy felt building paper is placed over the subfloor to provide insulation and to cushion the finished floor. Hardwood flooring is usually packaged in small bundles of random length pieces. It has a tongue and groove on the sides and ends to insure a good tight fit. Because it has this tongue and groove on the ends, cutting is eliminated except at the side or end of a room. Softwood flooring usually comes in standard length pieces with a tongue and groove on the sides, but not on the ends. It is necessary, therefore, to cut the pieces in order to break or stagger the joints. These cuts should be made exactly square across the face of the pieces. It is customary to undercut the flooring, as illustrated in figure 136, to make a good tight fit when the material is not end matched (with tongue-and-groove ends).

13-7. When laying flooring over old floors, all protruding nails must be hammered down, loose boards must be nailed, warped boards must be replaced, and high spots leveled. For best results, it is recommended that you machine sand the old floor before laying the new floor. Before sanding, the thresholds, base shoe, and baseboards should be taken up and the interior doors removed from the hinges. After sanding, the floor should be swept clean; building paper, usually 15-pound felt, should be placed on the floor before you lay the new floor. The new flooring should run at right angles to the old floor.

13-8. The first strip of flooring should be placed approximately ½ inch from the wall with the grooved edge toward the wall. This piece should be face-nailed close to the wall so that the nailheads will be covered by the baseboard and shoe mold. Each additional strip of flooring must be forced tightly against the strip previously nailed. This can be accomplished by hammering against a short scrap piece of flooring which protects the tongue, as shown in figure 137. Cement-coated nails are used for flooring because of their holding power. The nails should be driven on the tongue edge at approximately 50° to help draw the piece up tight. This is called blind nailing because the nailheads are covered by the next piece of flooring. When laying a floor, you should stand with your toes on the piece being nailed and bend over from the waist to drive the nail. By working in this position, you can hold the piece in place and drive the nail with an easy motion. Also, there is less possibility of damaging the piece when the nailhead reaches the board. The ends of adjacent pieces should always be staggered to prevent a continuous joint across two pieces. The end cut should be slightly undercut (less than 90°), as shown in figure 136. This undercut end is forced tightly against the end of a square cut board to make a tight joint.

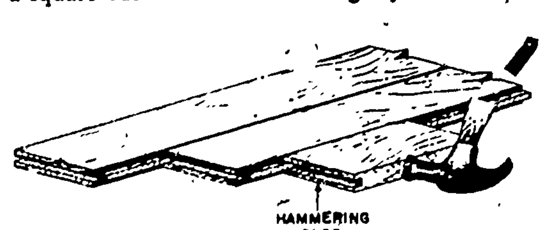



Figure 137. Laying flooring.



123

13-9. End-matched boards have the tongue and groove extending around the ends of the board, and the boards are of random length, making it easy to offset the end joints. Boards that are not end matched are cut square across the board, and it is up to you to space the end joints.

13-10. Wooden parquet floors consist of tile size wood blocks. Tongue-and-groove strips of wood are assembled to form square tile. Some tile are glued together, whereas others have several metal straps across the back of the strips to hold them together. Four or five strips are placed together to form a tile that is square.

13-11. The squares are glued to a slab or subfloor to form various designs. The usual pattern is to place the second tile with the strips running perpendicular to the strips in the first and third tiles. The grain of the wood in one tile runs perpendicular to adjoining tile. For this reason, you do not refinish these floors by using the usual sanding procedures.

13-12. **Maintenance of Wood Floors.** Wood flooring is easily maintained if it is kept clean and is not soaked with water during the scrubbing process. Most wood floors now have a wax finish and are under the control of user maintenance. Damp mopping and an occasional scrubbing by the user can do more to extend the serviceability of wood floors than we can. There are some areas at the bottom of stair wells and in front of exits and latrine doors that are exposed to excessive amounts of water. This water penetrates the finished floor, causing the edges of the boards to turn up and open some joints. The water passes freely through open joints to the subfloor and joists below. Some water remains in the joints and between the joists and subfloor and between the subfloor and finished floor. This same problem exists in many two-story barracks, even when tile or other coverings are used at the base of the stairs. When these problems are noted, the source of the water should be located. If the water is due to stair scrubbing and flooding, the method of cleaning the stair must be changed. If the water is entering the room through an exit door, the door will have to be put into good condition and properly fitted in the jamb. A metal flashing can be installed above the door to direct water away from the head jamb. A J-strip or other seal can be used between the bottom of the door and the threshold to stop the entry of water at this point. If you don't locate the problem in time to take corrective action, then you may need to replace some flooring.

13-13. *Subflooring.* The subfloor is also known to some craftsmen as underfloor, rough floor, or base floor. It is laid directly on top of the floor joists and helps to strengthen and aline the top edge of the joists. It serves as a nailing surface for the finish floor. The joints in the finish floor (unlike wall siding and roof sheathing) are at random intervals and are not necessarily located on the joists. Subflooring also helps to deaden sound, insulate, and prevent dust from rising upward through the finish floor.

13-14. The replacement of subflooring, either boards or plywood, is done by cutting out the damaged portion of the subfloor and replacing the subfloor with like material of the old subfloor. It is done in the same way as that discussed in Chapter 2 on the installation of subfloors. The last piece to be put in place of tongue-and-groove material should have the bottom groove removed before it is installed and nailed into place.

13-15. *Finished floor.* It may be necessary to replace damaged pieces of finish flooring when it is worn thin, marked, or buckled. The section to be replaced can be removed, as shown in figure 138, by boring a hole 2 inches below each end of the damaged areas and cutting squarely across the piece with a keyhole saw. The piece can easily be lifted out if the joints are not tongue and groove; however, a chisel can be used to split the piece out between the two saw cuts.

13-16. When the damaged piece has been removed, a new piece of flooring should be cut to fit tightly into the section being repaired. Before inserting the piece into the hole, the bottom part of the grooved edge must be removed so that it will slip into place easily. After the piece has been placed, as shown in figure 139, it should be face nailed with finishing nails. If the piece is likely to split, holes should be drilled for the nails. The heads of the nails are set slightly below the surface and are covered with wood filler before the finish is applied to the floor.

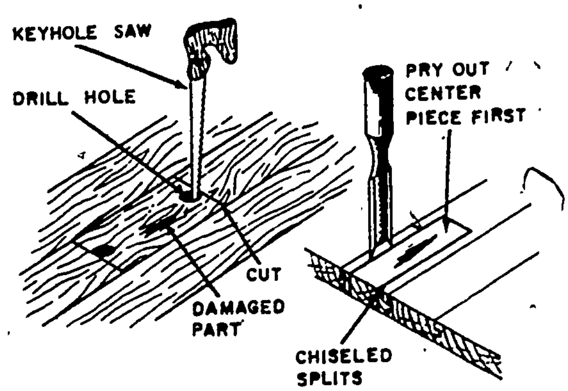



Figure 138. Damaged flooring removal.

231

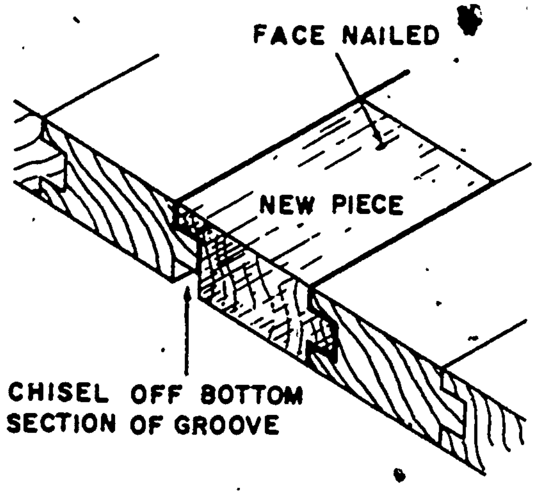



Figure 139. Flooring replacement.

13-17. Repairs of wood parquet floors usually consist of filling and hand sanding or replacing units. Use extreme care when removing a tile to prevent damage to the edges of the adjoining tiles. Work from the center of the tile outward to prevent this damage to adjoining tile.

13-18. **Nonwood Floor Coverings.** These coverings consist of the various kinds of tile and linoleum that are used as a floor surface. There are very few installation problems when these coverings are used on new floors that are prepared for them. To place them over old floors usually requires some additional work to prepare the surface. Before any of the nonwood flooring materials are applied over wood floors, all loose boards should be adequately nailed, cracks should be properly filled, and the entire floor should be machine sanded. When a concrete base is to be covered, it should be clean, dry, and free of dust. If the floor is below ground level or over a poorly ventilated area, the wood or concrete base may be affected by moisture. In this case, asphalt tile is usually recommended because other floor coverings may be damaged by moisture.

13-19. Wood floors which have become unsanitary or hazardous may be economically repaired by application of a flexible or semirigid floor covering. Let's discuss some of these materials to see how they are used.

13-20. *Felt.* The use of felt under most nonwood floor covering is recommended because it will lengthen the life of the covering. The felt is available in rolls 3 feet wide. It should be cut to fit around pipes and other obstructions. Where two strips of felt join, they should be butted together. The edges should never be overlapped because the double thickness will create an uneven base, thus causing uneven wear of the finish covering. The felt iu cut for an entire room before any of it is pasted down.

13-21. *Plywood.* Plywood underlayment should not be less than ⅜ inch thick, 3 ply, with moisture-resistant glue.

13-22. *Fiberboard.* Hard fiberboard for underlayment should be ¼ inch thick. Fiberboard is made by compressing fibers of wood or other substances into thin, stiff sheets. It is commercially available in standard 4 x 8 sheets.

13-23. *Semirigid board.* A semirigid asphalt saturated board is available in thicknesses of $\frac{3}{16}$ and ¼ inch, and a sheet size 36 x 40 inches. This board, highly resistant to moisture, will not warp or buckle when exposed to high humidity. It can be cut and trimmed with a linoleum knife.

13-24. *Trowel-applied underlayment.* This underlayment consists of floor mixes laid to a thickness necessary to provide a smooth surface. These troweled-on underlayments may be described as latex-type leveling course, asphalt-type leveling course, floormastic, latex liquid felt, etc.

13-25. *Linoleum.* Sheet linoleum is laid in practically the same way as felt. It should be scribed accurately, as shown in figure 140, to fit any irregularities in the wall. When one strip of linoleum has been cut to fit the room, it is usually pasted in place before the second piece is cut. The paste is an adhesive used according to factory specifications for sticking the linoleum evenly and firmly over the complete floor surface.

13-26. *Asphalt tile.* Asphalt tile is suitable for installation over most wood and concrete floors. Asphalt tile is available in many plain and marbleized colors and not only presents an attractive appearance but also offers other important advantages. It is quite comfortable to walk on, extremely durable, and highly resistant to abrasive action of foot traffic and such common abuses as scuffing and cigarette burns. It is an odorless,

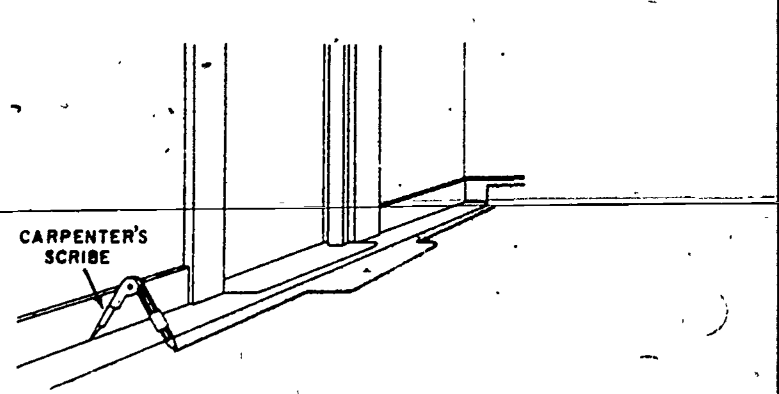



Figure 140. Scribing floor covering.

232

nonabsorbent covering that does not originate dust and is easy to clean and maintain.

13-27. *Other tiles.* Plastic, rubber, plastic asbestos, cork, and vinyl tile are some of the tiles other than asphalt. The application of these tiles is similar to that of asphalt tile, so we will confine our discussion to asphalt tile.

13-28. **Laying Tile.** The first step in laying tile, of course, is smoothing the area by sanding (wood floors), placing underlayment, or both, and placing a layer of felt over the prepared surface.

13-29. The second step is layout. This step is often neglected. It is a very important part of the job and should be well planned. Problems will develop after the tile is laid if narrow (1- or 2-inch) strips of tile are placed around the perimeter of the room. You should also consider the shape of the room to be tiled. Rooms that are not square are difficult to tile correctly. Let's plan several jobs so that you will be able to do the layout on your own.

13-30. Using the standard 9- x 9-inch tile as our material, let's lay out a very small room for tile. Let's say the floor is 3 feet square. Our 9- x 9-inch tiles will fit evenly in a 36-inch area. To lay out the area correctly, we merely locate the center of each wall and make a chalkline, marking the center points on opposite walls. The center of the X will be in the center of the room and 18 inches from each wall. We need two tiles placed edge to edge along the line and two along the wall to fill each quarter section of room.

13-31. Now, let's try a room 40 inches square. Our centerlines will be 20 inches from the walls, or two tiles and 2 inches from each wall. This brings up a problem, because the 2-inch strip along the edge (laying tile from the center outward) may turn up on the edges or slip out of place. Chair and desk legs will catch on the tile, or the weight of a cabinet or desk may break the tile. There is no rule that tells us not to lay a 2-inch strip of tile, but maintenance men certainly wish that one existed. A good guide to follow is to use tile at least 4½ inches wide. You couldn't tile our sample room using the centerline method or the wall-to-wall method and follow our guide. You would have a 4-inch strip if you applied the tiles by starting at one wall and working across to the opposite wall. This is not the preferred method of laying tile because the lack of symmetry is so obvious in a small room or one that is not square. The joints will not be parallel with the walls, and strips of tile along the edges will be of different widths that almost anyone can distinguish from a rectangle. The solution to our problem is to move the starting line from the center of the room.

13-32. We move the line 4½ inches (one-half the width of the tile) in either direction. This will increase the measurement on one side of the room and decrease the other side. In effect, it will add a half tile to one side and take it away on the other. We add the 4½ inches to our 2-inch strip, and now we have a 6½-inch strip and two full tiles on one side of the starting line (6½ + 9 + 9 + 9 = 24½ inches). We subtract the 4½ inches from the strip on the other side of the line. We cannot subtract 4½ from 2, so we add a full tile (9 inches) to the 2 inches for a total of 11 inches. Now we subtract 4½ from 11 and get 6½ (11 − 4½ = 6½), or the width of our edge strip. We now have one row of 9-inch tiles and one row of 6½-inch strips on this side of the line for a total of 15½ inches (9 + 6½ = 15½). This 15½ plus the 24½ equals 40 inches, or the width of our room.

13-33. Let's try a larger area and lay it out for tile. Let's say that we have a floor 10 feet wide and 11 feet long to cover with asphalt tiles, which measure 9 x 9 inches. Let's lay out the floor as shown in figure 141. We start by establishing the centerlines from wall to wall. Call the shorter line the layout line and the longer one the starting line, because we may move them from the center as the work progresses. Now, we figure the number of tiles it will take to lay a row along the 11-foot length of floor.

13-34. Eleven feet equals 132 inches (11 × 12 = 132). Dividing this by the size of the tile (9 inches) gives the number of tiles needed to lay one row the length of the floor. Nine divides 132 inches 14 times with 6 inches left over. Putting half of this on each side of the layout line will give us 7 tiles and a 3-inch strip (14 tiles + 6 inches ÷ 2 = 7 tiles and 3 inches). We don't want to use a 3-inch strip, so we need to move the layout line 4½ inches. This will give us 7½-inch border strips (4½ + 3 = 7½), as shown in figure 141.

13-35. The 10-foot width equals 120 inches (10 × 12 = 120. Dividing 120 inches by 9 gives us 13 tiles and a 3-inch strip. What will we do with this one? Don't move the line because of the 3-inch remainder. When you place an odd number (3–5–7) of tiles along the line, you will find that the line doesn't need to be moved. This is true when the number of tile is odd and the remainder is less than half the width of a tile. Refer to the tiles placed beside the relocated layout line in figure 141. Note that there are 6 tiles and a 6-inch border strip on each side of the center.

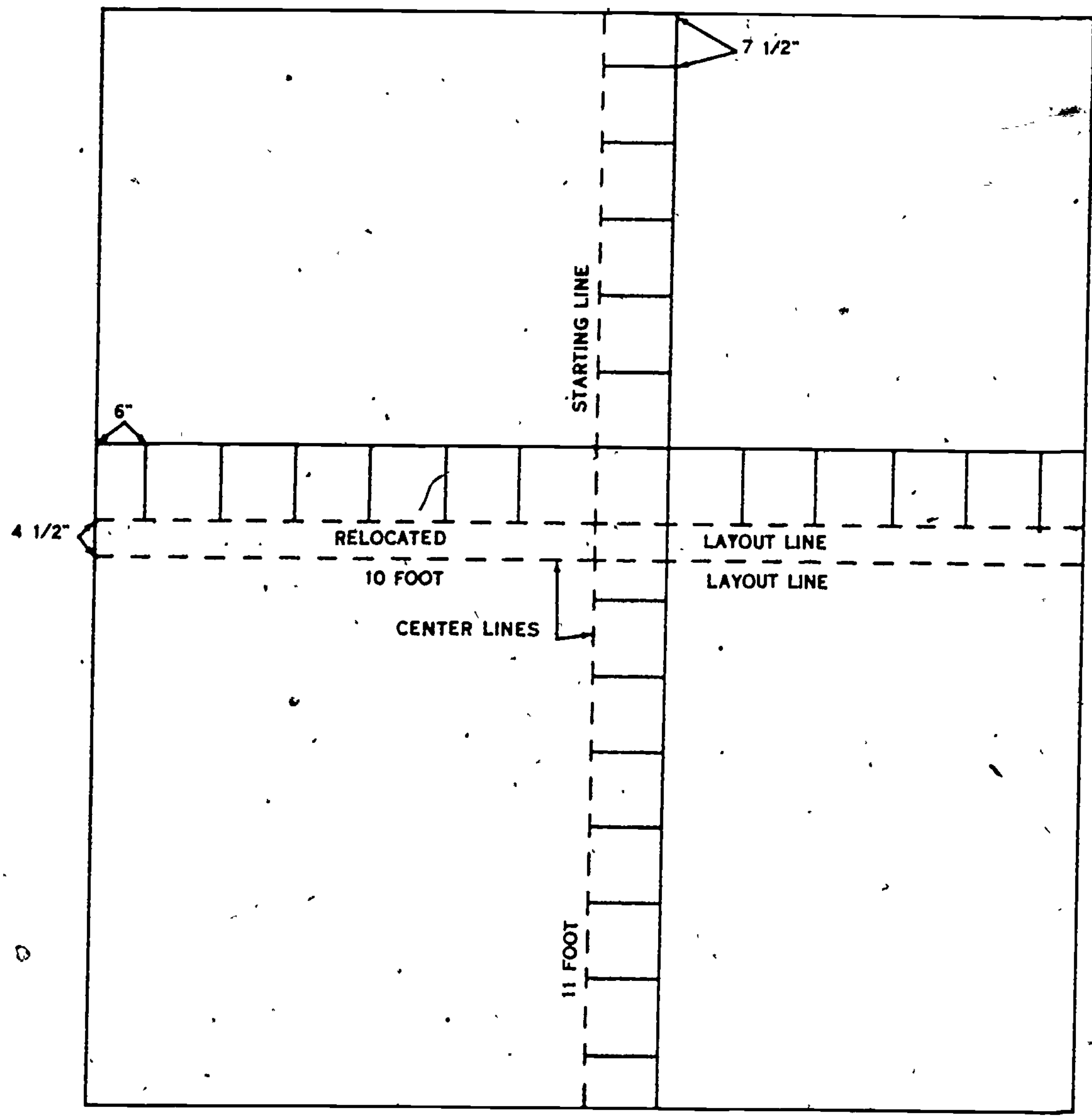



Figure 141. Tile layout.

13-36. Now that we know how many tiles are needed to lay a row across the room and how many rows are required, we can figure the total number of tiles needed to cover the floor. We need 15 tiles in a row and 14 rows. We multiply the number of tiles in a row (15) times the number of rows (14) to get (210) the total number of tiles needed ($15 \times 14 = 210$). This figure doesn't allow for tiles that are broken in the shipping container or on the job, so it is best to allow some extra tiles for waste.

13-37. Another method commonly used to figure the quantity of tiles is to use the square foot method. First, determine the number of square feet of floor surface by multiplying the length of the room by the width ($11 \times 10 = 110$). Divide the number of square feet by $\frac{9}{16}$ square foot, the amount of surface covered by one 9- x 9-inch title. $110 \div \frac{9}{16} = \frac{110}{1} \times \frac{16}{9} = \frac{1760}{9} = 1760 \div 9 = 195.55$. This is the least number of tiles required to cover the floor surface, regardless of the method used to lay them. We know that we must cut and fit border tiles to have a lasting floor, so we must allow some extra tiles for the job. Allowing 10 percent for waste will give you an additional 19 tiles, or a total of 214 tiles for the job.

13-38. The next step is to spread the adhesive, which in this case is asphalt-tile cement. This cement is usually a cutback cement. The asphalt is mixed with a liquid that keeps it flexible during storage. After application, the liquid evaporates, leaving the asphalt adhesive.

13-39. You must stir the cement in the container to mix the adhesive and liquid to a uniform consistency. Use a paddle-shaped piece of wood to place some of the adhesive near the starting point in the center of the room. Lay one quarter of the room at a time. Spread the adhesive from the starting point along the starting line to the wall (refer to fig. 142). Use a notched trowel to spread an even layer of adhesive over the entire quarter of floor space (marked as first quarter in figure 142).

13-40. Allow the adhesive to dry until the gloss is gone and the surface is tacky and appears dry. Laying tile before the adhesive is dry is just as bad as laying tile when the adhesive is too dry. Tiles placed on adhesive that is still

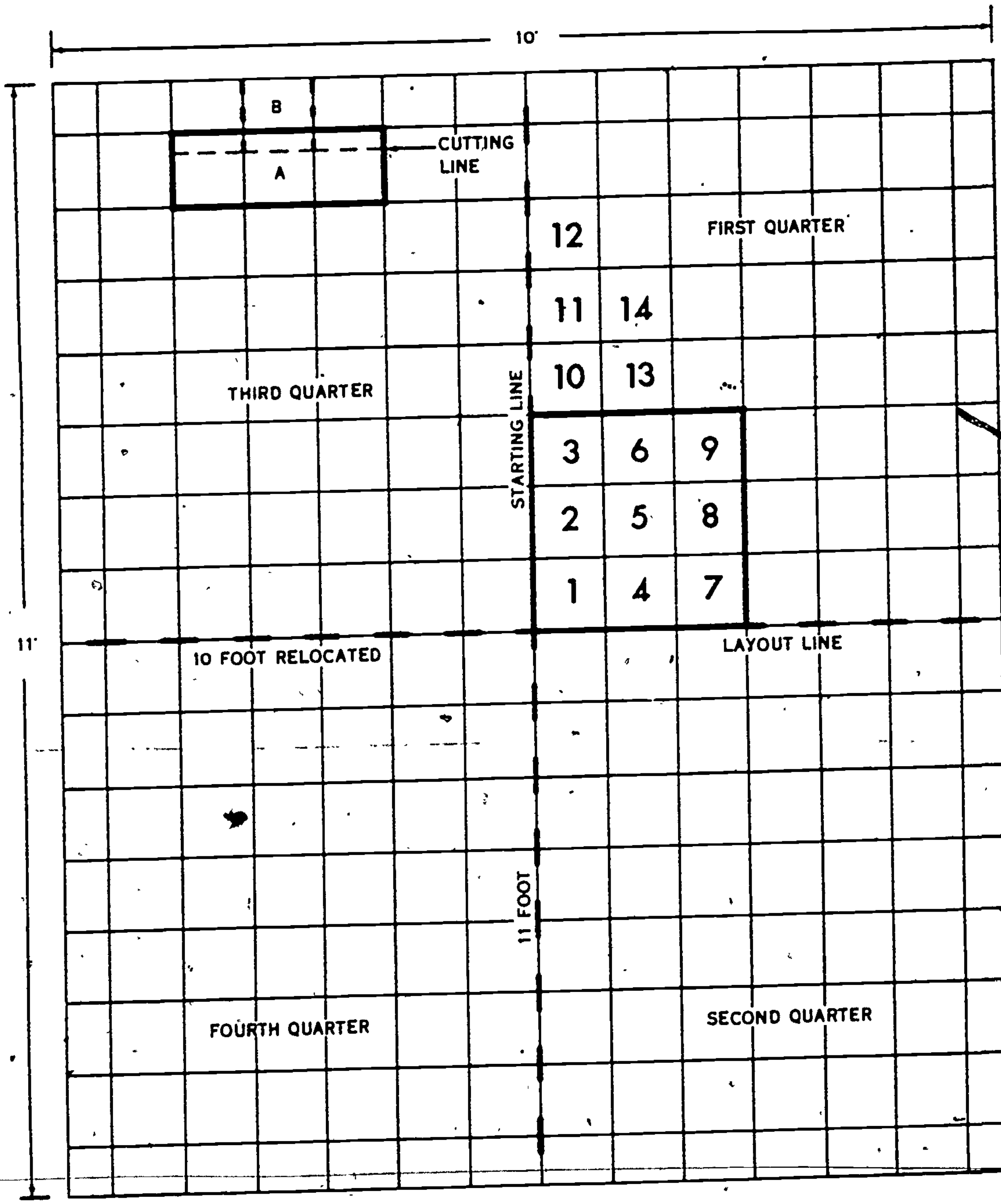



Figure 142. Layout and tile work.

95

wet will prevent the adhesive from drying and the tiles will be subject to slippage. Tiles placed on an adhesive that is too dry will not stick securely and will produce a hollow sound when you walk on them.

13-41. The first tile is placed at the starting point in the center of the room as shown by tile No. 1 in figure 142. The shiny, smooth side of the asphalt tile is placed upward as the wearing surface. The second and third tiles are placed along the starting line with the first tile. The fourth tile is placed beside the first tile, the fifth beside the second, and the sixth beside the third. This will give you two rows three tiles long. A third row is made beside the second to form a square as shown in figure 142. The important part at this time is to insure that the first three tiles are parallel with the starting line and that the second and third rows of tile are alined to form neat joints with the first row. Avoid moving these tiles any more than is absolutely necessary. However, the joints in the entire floor depend on this starting section.

13-42. Succeeding tiles are placed along the centerline and toward the corner by placing the edge of the tile against one that has been laid and snapping it into place. If tiles are laid on the adhesive and slipped into place, adhesive will build up in the joints. The tiles are pressed firmly in place to insure complete adhesion.

13-43. Border tiles may be cut with a tile cutter or a shingle cutter, or by scoring and breaking. Irregular cuts are made by heating the tile (from the back side) and cutting with an old pair of snips or a linoleum knife Apply the heat slowly until the tile is flexible. Excessive heating will cause the tile to blister and darken or turn brown.

13-44. Border tiles or tiles that must be cut to fit around obstructions can be measured as shown at the top of figure 142. When the last row of full tiles is laid, you can place the row of border tiles squarely on top of it, as shown by tile A. Tile B, also a full 9 x 9 tile, is used to measure from the wall to the cutting line across tile A. Scribe along the side of tile B to mark the cutting line on tile A This system works well around door jambs, columns, etc., where a close fit is required.

13-45. After the first quarter is laid you can lay the second quarter, and then the third and fourth quarters. Don't walk on the tiles any more than is necessary before they are firmly set in the adhesive.

13-46. If asphalt cement gets on the surface of a tile, you can remove it by rubbing it with a clean cloth, or a cloth saturated with a mild soap. If this does not get satisfactory results, you can use fine steel wool (lightly) or wet scouring powder. Paste floor wax applied to the area will soften the asphalt so that you can wipe it off with a rag and avoid any scratches that might be made by steel wool or scouring powder.

13-47. **Replacing Asphalt Tile.** Tile that is broken, chipped out, or loose requires replacement to remove hazards or to protect wood flooring underneath.

13-48. Single tile may be removed by chipping out with a hammer and a cold chisel. Applying heat to the surface will loosen the tile from the cement so that you can lift it out with a putty knife. A garden hoe or hoe-shaped scraper can be used to remove large areas of damaged tile. Make certain that all pieces of tile and loose adhesive are removed and that the remainder of the old adhesive is smooth before the new cement is applied.

13-49. After the tile is removed, you can apply a very small amount of adhesive over the old adhesive to hold the new tile in place. Apply the cement with a putty knife when you are replacing a single tile. In this way you can work carefully and avoid getting the cement on the adjoining tiles.

## 14. Stairway Construction

14-1. The stairway is an important section in building construction. A staircase, when carefully designed and built, adds dignity and charm to a home. The quality of craftsmanship reflects the character of the entire building, since stairways are usually located near the main entrance. Exterior stairways are sometimes used as porch steps and as fire escapes on two-story buildings. Because of the importance of good solid stairs from a safety standpoint, you may do a lot of repair and replacement work on these stairways.

14-2. **Stair Design.** A stairway commonly known as a straight flight stairs is shown in figure 143. It is the simplest to build but not necessarily the most desirable for all conditions.

14-3. The layout of a building does not always permit the use of a straight flight stairway. A stairway with a long flight consisting of more than 15 steps is tiring, because it affords no opportunity for a pause in ascent. For this reason a landing should be introduced somewhere in the flight, usually at the halfway point, as shown in figure 144. Landings also have another function, that of changing direction, as shown in figure 145.

14-4. The width of a stairway is determined by the need for two people to pass comfortably on the stairs and by the fact that equipment

236

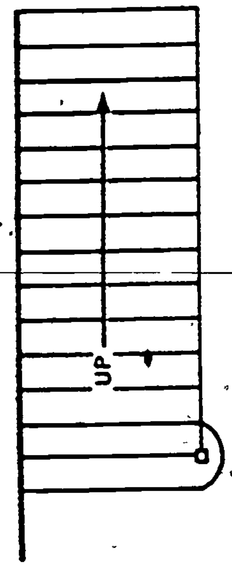



Figure 143. Straight flight stairway.

may at some time or another be carried up or down. One person can use a stair 2 feet wide; but if two people are to be able to pass on the stairs, the width must be at least 3 or 3½ feet wide.

14-5. The width of exterior steps usually extends to the outer edges of the door trim or at least the width of the door opening.

14-6. **Stairwell.** The stairwell is the opening in the floor where the stairs are located. The framing for the stairwell begins with the placing of the floor joists and includes the installation of the stair stringers (carriage or stair horse).

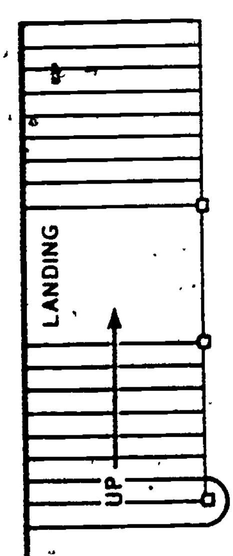



Figure 144. Straight flight stairway with a landing.

The members around the opening are doubled or tripled to provide adequate support, as explained in the discussion on floor framing in Chapter 2 of this volume.

14-7. The size of well holes varies. Ordinarily, they are wide enough to allow two people to pass on the stairs without difficulty and long enough to give adequate headroom according to the steepness of the stairs. Headroom is the clearance measured vertically from the top of a tread to the underside of the stair or ceiling above. (See fig. 146.) Seven and one-half feet of clearance is satisfactory for headroom on normal stairways, but steep stairs should have slightly more clearance.

14-8. The tread widths may vary slightly, but a governing rule to follow, which limits the tread width, is to make the tread width dependent on the riser height. One tread width and one riser height added together should be between 17 and 18 inches; or the height of two risers and width of one tread added together should not exceed 25 inches. For example, if the riser height is 7 inches, the most desirable height, the tread width would be between 10 and 11 inches.

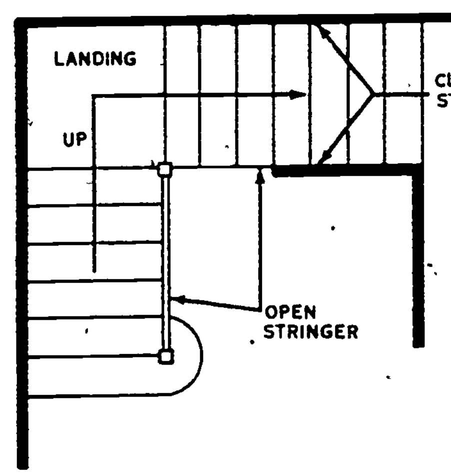



Figure 145. 90° change with a landing.

14-9. The material available for use as the tread boards will often determine the width of tread to use. If regular 11½-inch stair tread material (a standard 2 x 12) is used, the tread width should be 10 inches, with 1½ inches allowed for the nosing which extends over the riser, as shown in figure 147. A cove or quarter-round molding is used to cover the joint made by the nosing and riser. When the riser height is 7½ inches, a 2 x 10 piece which

237

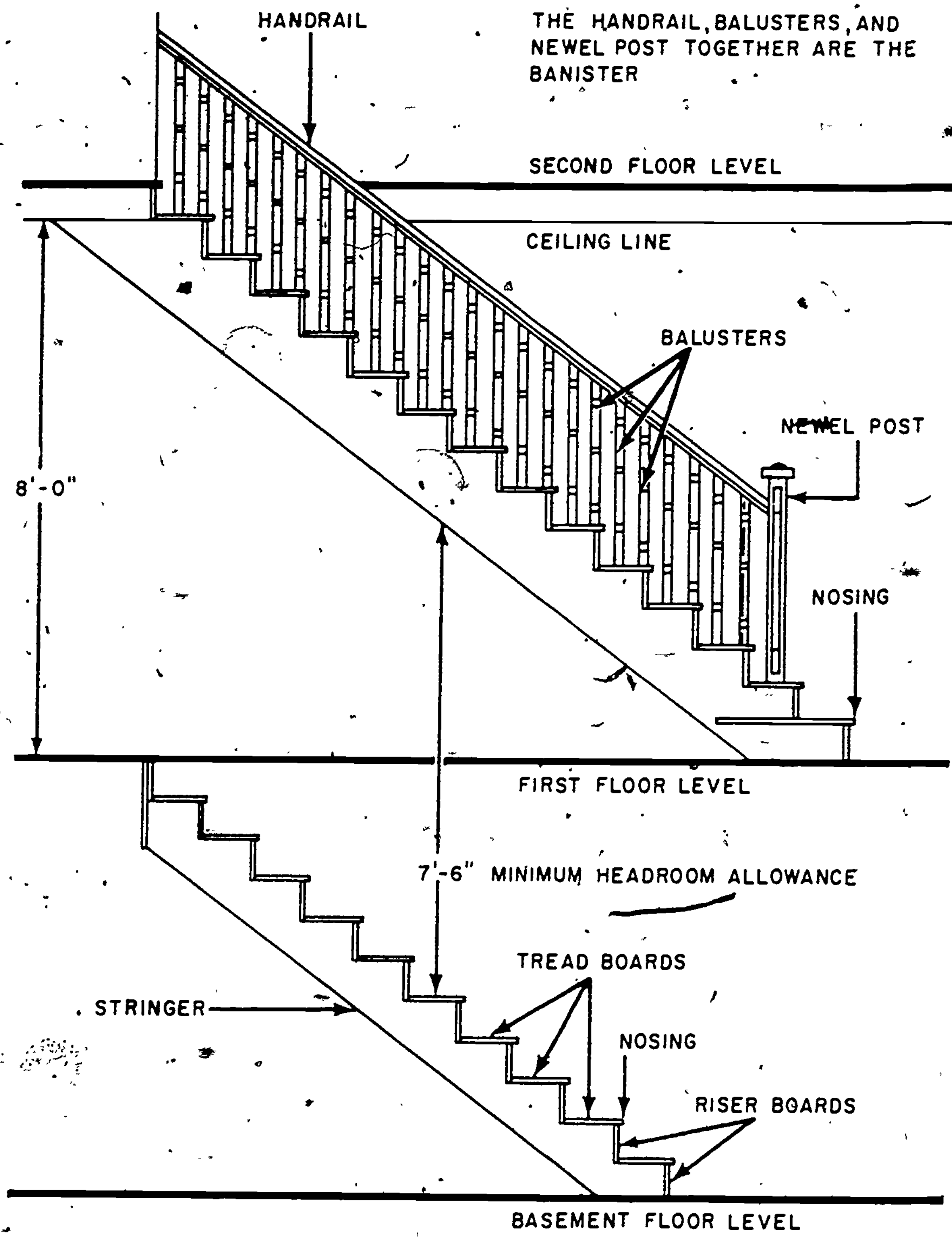



Figure 146. Nomenclature of stairs.

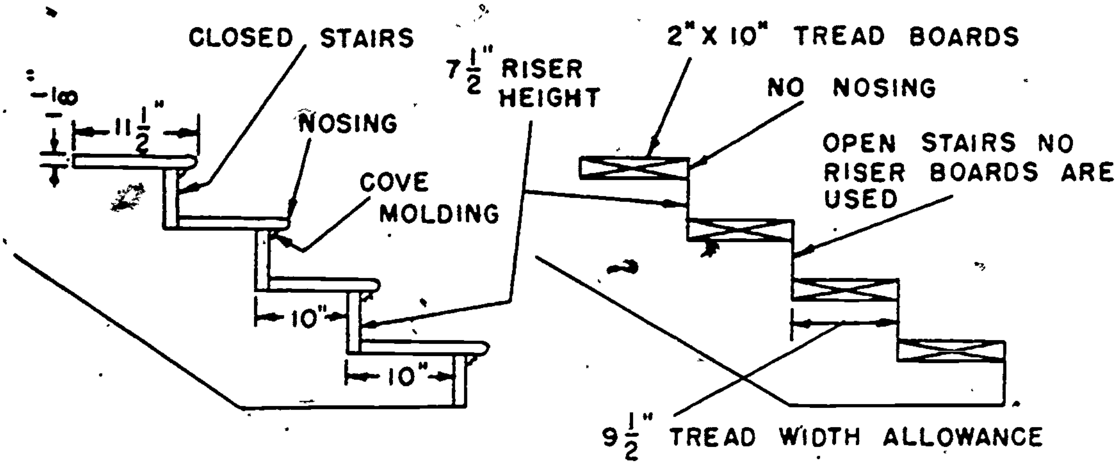



Figure 147. Tread width allowance.

measures 9½ inches may be used for the tread boards. When this is done, the nosing is flush with the riser, as shown in figure 147, and the risers are left open.

14-10. **Stringer Layout.** The stringers are the supporting members for stairways. One stringer is used on each side of the stairway. On wide stairs, a third (center) stringer is used in addition to the outside set. When three or more stringers are used, the center ones are completely hidden and are usually cut from rough material. For this reason they are commonly referred to as rough stringers.

14-11. The layout of a stringer is based on the vertical distance from one floor level to another (total rise). The riser height and tread width must fit within the allowable space and must conform to the safe slope of 30° to 35°. For maintenance this is no problem, so let's create a simple project of our own. Let's make a set of stringers for use between the porch and ground level. The porch floor is 30 inches above the ground, so you can use 30 inches as the total rise of the stringer.

14-12. Use 7 inches as the preferred riser height and determine the number of risers required on the stringer. The number of risers on the stringer is determined by dividing the total rise (30 inches) by the desired riser height (7 inches). This is illustrated in figure 148,A. Seven will not divide into the total rise evenly, so you take the number of risers (4) and divide this into 30 to get the measurement in inches as shown in figure 148,B. Dividing 30 by 4 gives you 7.5, or 7½ inches as the riser height. You need 4 risers 7½ inches high on your stringer.

14-13. The tread width can now be determined by using our rule of rise plus tread equaling 17 or 18 inches. Seven and one-half plus 10 would be within the rule, but it would be the maximum allowed by the rule—that is, riser plus riser plus tread equalling no more than 25 inches. If the footings are located at 40 inches from the porch (4 treads, 10 inches wide) and you have the 2 x 12 tread material, you are ready to lay out the stringer.

14-14. The material to be used for the stringer must provide adequate support (after it is notched for treads and risers) and must have one straight edge (working edge). A 2 x 12 is satisfactory in most cases, and you can use one for this 30-inch height.

14-15. The next part of the job is to set up a framing square with gauges or a fence, as shown in figure 149. If you don't have a set of gauges, the fence can be made with a piece of 1 x 2 and a few bolts. The fence is placed on the square

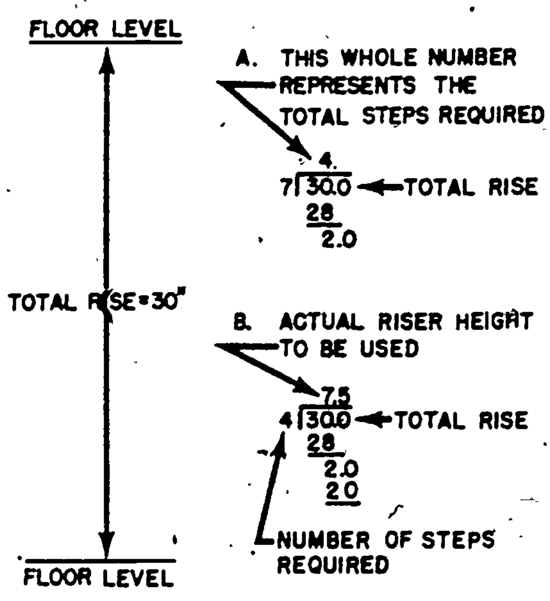



Figure 148. Determining riser height.

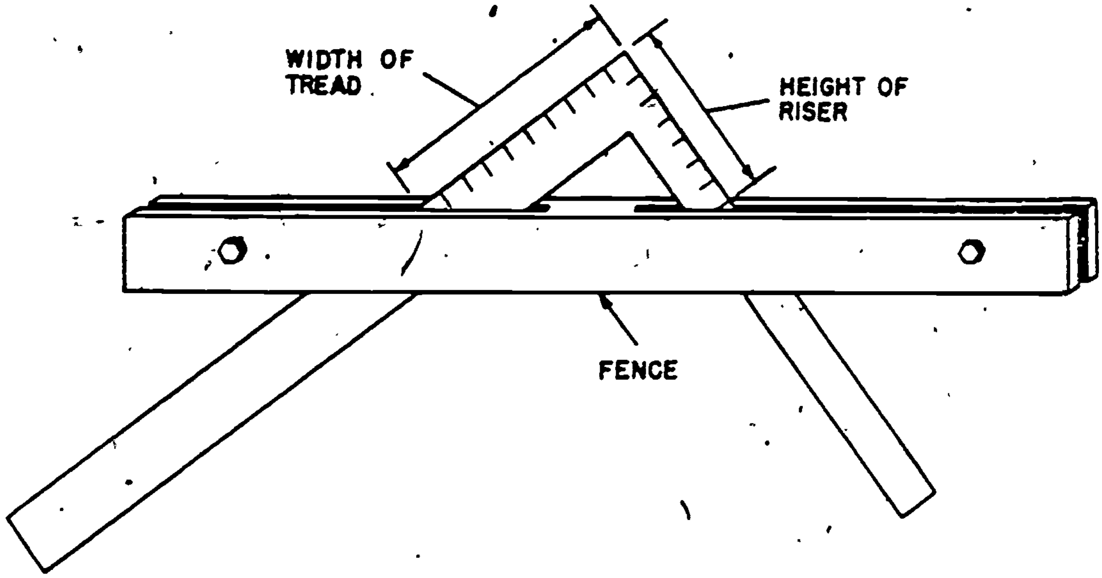



Figure 149. Fence for a framing square.

(loosely) and the square is placed on the stringer with 7½ on the tongue and 10 inches on the blade on the edge of the 2 x 12. The square is held firmly in place, the fence is moved to the edge of the 2 x 12, and the bolts are tightened to secure it to the square. The fence is an aid in repeating identical measurements and is recommended for use in stringer and rafter layout work. You can make the measurements freehand if you don't have the fence.

14-16. The square is placed in position on the straight edge of the stringer material, as shown in figure 150. The 7½-inch measurement is the rise height (rise), and the 10-inch measurement is the tread width (run). The square is placed (first position) about 20 inches from the lower end of the material to mark the second riser and the first tread. Then it is moved toward the lower end, and the first riser is marked. The tongue of the square meets the mark for the first tread at the edge of the material, as shown in figure 151. The fence is held against the straight edge of the material while the mark is made along the outside edge of the tongue of the square to mark the first riser.

14-17. The square is held in this position while the thickness of the first tread is subtracted from the height of the first riser. This subtraction is necessary to compensate for tread thickness. The

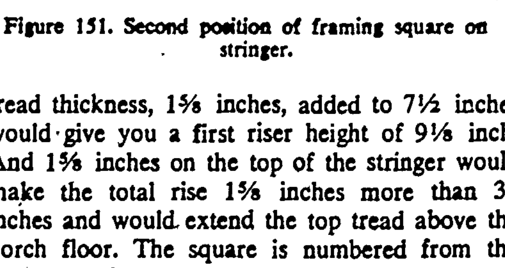



Figure 151. Second position of framing square on stringer.

tread thickness, 1⅝ inches, added to 7½ inches would give you a first riser height of 9⅛ inch. And 1⅝ inches on the top of the stringer would make the total rise 1⅝ inches more than 30 inches and would extend the top tread above the porch floor. The square is numbered from the heel toward the end of the tongue so that you can make a mark at 1⅝ inches, designating the bottom of the stringer, as shown in figure 152.

14-18. The square is moved up the edge of the stringer to where the edge of the blade and the mark for the second riser meet at the edge of the board. A mark around the heel of the square

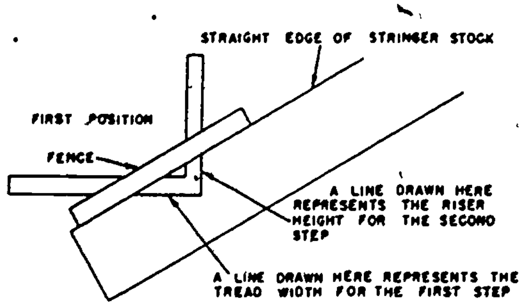



Figure 150. First position of framing square on stringer.

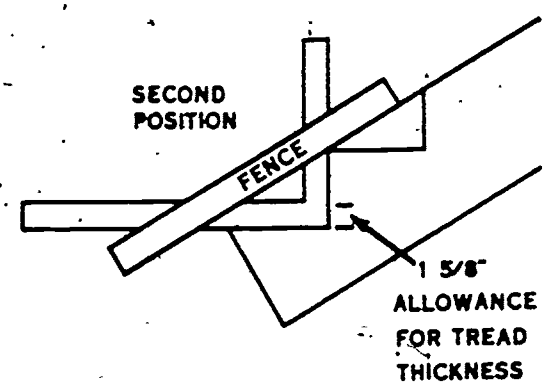



Figure 152. Laying out riser height for first step.

marks the second tread and third riser. The square is moved upward in this manner until all the treads and risers are marked, as shown in figure 153.

14-19. The square is moved to the opposite edge (back) of the stringer, and marks are made at the bottom of the first riser and at the cutoff point at the top of the stringer. As long as the fence is held against the edge of the stringer, you can make horizontal marks along the blade and vertical marks along the tongue of the square.

14-20. Figure 154,A, shows the stringer notched to fit over a ledger board. The ledger board is secured to the stringer and is then fastened to the porch header or joist to form a solid support for the steps. The bottom of the stringer is notched out for a 2 x 4 kick plate. The plate serves as a tie, holding the bottom edge of the stringers in position, and as a means of fastening the steps to the concrete footings (if required). The bottom of the stringer should not be placed on the ground, and long stringers, such as fire escapes, should be secured by using anchor bolts through the kick plate into the footings. Figure 154,B and C, show two other methods of stringer attachment for steps and stairs.

14-21. Check all your measurements after you finish marking for the ledger board and kick plate. This first stringer can be cut and used as a pattern to mark the other stringer. After the second stringer is cut, you can cut and place the riser and tread boards and molding.

14-22. The riser boards are nailed in place first; then the tread boards are nailed in front of them. Nailing through the back of the riser into the tread will help support the back edge of the tread, as shown in figure 155. Also shown in figure 155 is the use of tongue-and-groove risers and treads. This type of construction gives additional support to the stairs. When riser boards are not used, the tread is butted against the riser cutout. This is the usual method for porch steps such as those in our sample project.

14-23. **Stairway Maintenance.** Stairways wear out and need repairing, and porch or entrance steps become weathered and need replacing. Some steps now in use are a partial copy of other

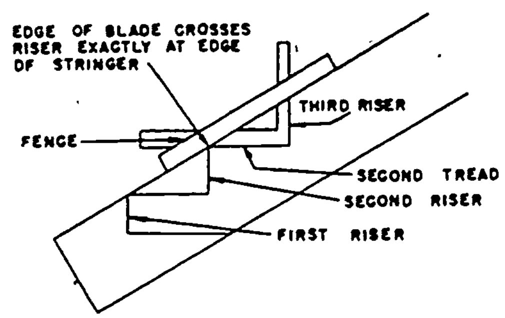



Figure 153. Third position of framing square on stringer.

steps, the salvaged ends of stringers designed for another building, or the result of trimming a set of used steps for use in a different area. All of these steps are staisfactory if they meet the requirements of good stair construction. You will be replacing some stairs (probably exterior), so let's discuss the things you need to know about them so that you will be equipped to correct any faulty set of steps.

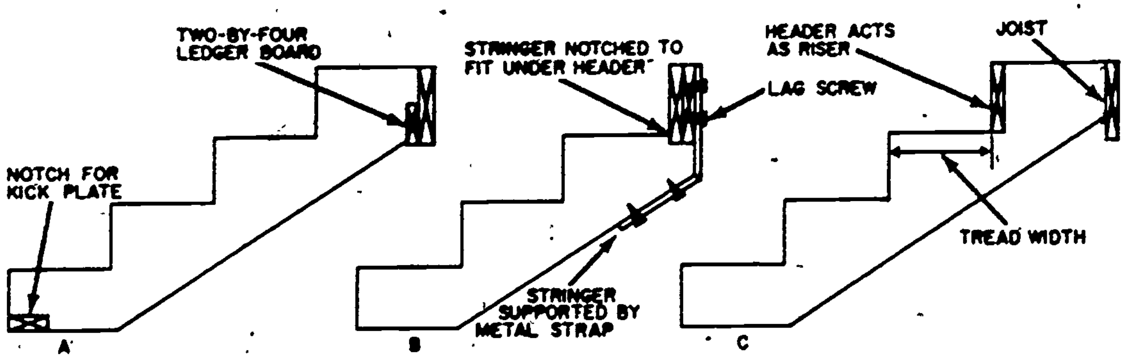



Figure 154. Anchoring stringers.

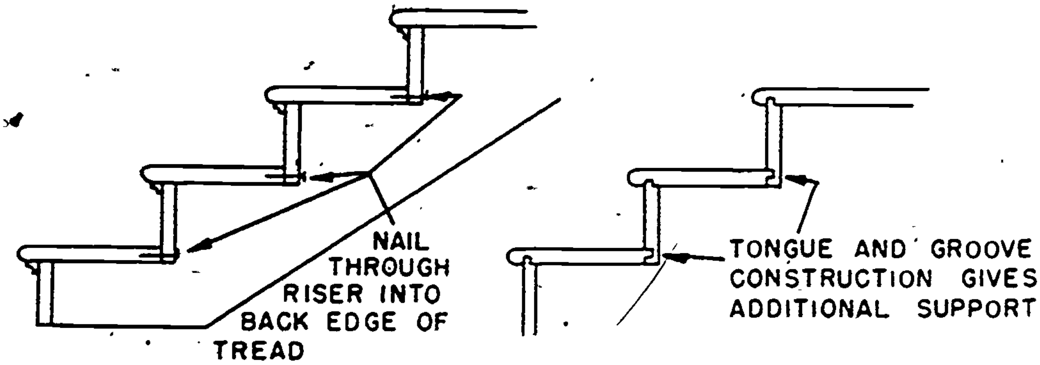



Figure 155. Installing treads and risers.

14-24. Falls suffered on stairs are the most common of all building accidents. Falls are caused by undue haste, poor stair illumination, and defective or improperly designed steps. These two statements are common to safety practice. See EM 385-1-1 for additional guidance in safety requirements. Both carelessness of personnel and negligence in maintenance may be responsible for accidents. Of course we can't be everywhere at once, and some things could not be prevented even if we were there. But, we know that many of the jobs we do are done solely for the protection of personnel, so let's see that these jobs are done right.

14-25. The slope for a stairway should be between 20° and 50° from the horizontal, with 30° to 35° preferred. This slope is easier for most individuals (all ages) to climb. A tread width of not less than 9½ inches, with a nonslip nosing of 1 inch, is recommended. The riser height should not exceed 8 inches nor be less than 5 inches, and it should be the same for each riser in a flight of stairs. Stairs so constructed are relatively easy and safe to climb. An odd size riser

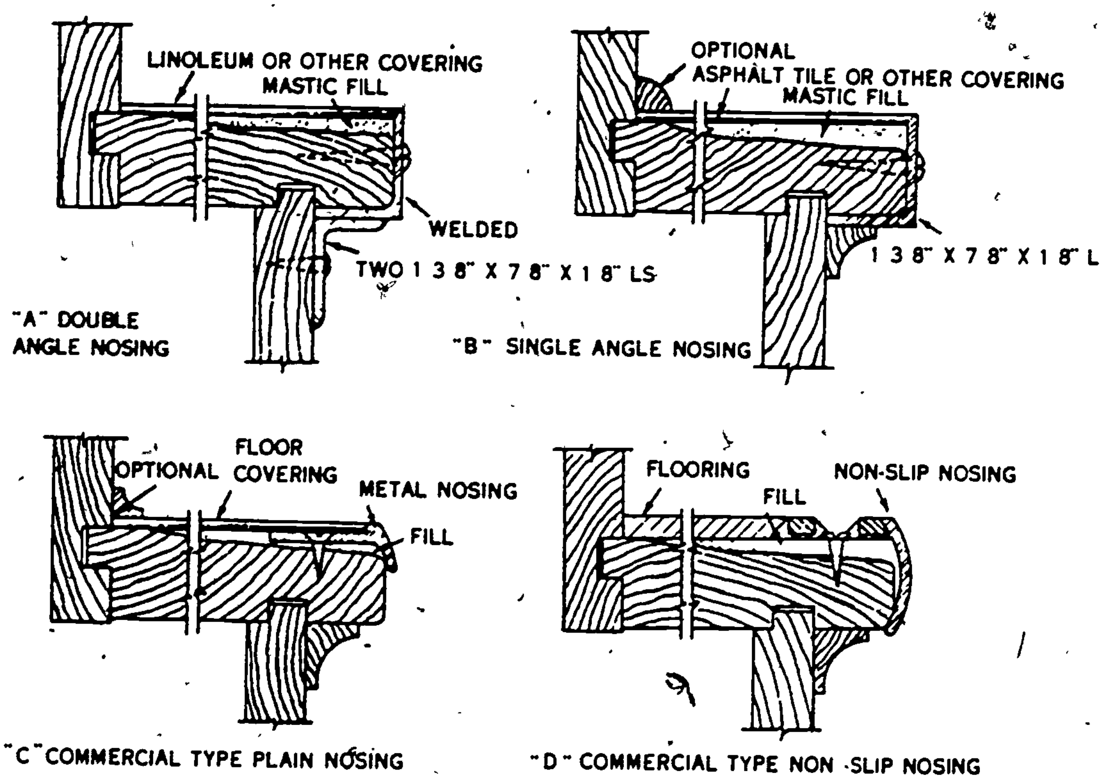



Figure 156. Repairing worn tread.

242

or tread located in the stairs will cause a person to trip, fall, or stop with a jar.

14-26. Perhaps you will notice the difference in steps most when you report to a new post. You enter a strange building by climbing a short flight of steps, and when you get to the top step you find that your foot doesn't reach it. Is the leg too short or is the top riser narrower than the others? As the foot reaches the tread, you get a jar that twists the back and causes your hat to bounce. Of course you check the steps and make a mental note to remember this incident when you leave the building.

14-27. All parts of the stairway must be firmly attached to the structure. Worn parts must be repaired or replaced before they become a safety hazard. Many commercial nosings are available for use on stair treads. They are made of steel, brass, bronze, aluminum, or rubber and are formed with a nonslip surface. Special rubber and metal nonslip strips are available to cover the entire surface of the tread.

14-28. Special care must be taken in setting the nonslip nosings on worn treads. The nosing must have a firm, even contact for the full length of the tread. Worn treads are usually built up with a mastic filler, as shown in figure 156. Two metal 90° angles may be used as a solid edge on the nosing. The tread surface is covered with linoleum or tile, as shown in figure 156,A. This repair will renew the step to a durable and safe condition. A single angle and cove molding may also be used to rebuild a nosing, as shown in figure 156,B.

14-29. Commercial tread nosings may also be used to rebuild treads, as shown in figure 156,C and D. Screws are preferred for fastening the nosings in place because they do not work loose as easily as nails.

243

# EXAMINATION

ARMY CORRESPONDENCE COURSE • ENGINEER SUBCOURSE 532-0

## CARPENTRY II (Frame Construction)

CREDIT HOURS ........................ 2

TEXT ASSIGNMENT .................... Review previous study assignments in Memorandum 532.

### EXERCISES

1. After you have determined the location and alinement of a building, what do you do next?

a. stake out the building

b. square the building

c. start excavation

d. establish inside dimensions

2. If the selected building site is not level, where would you locate the first batter board?

a. at any point

b. third corner

c. second corner

d. highest point

3. What would you have to do at many buildings sites before the foundation can be correctly located and firmly supported?

a. drive in the bearing piles

b. excavate building site

c. erect concrete form

d. pour support footings

4. You are constructing a long-wall type foundation, and you have extremely limited time. What type form do you use?

a. continuous wall

b. full unit

c. layer unit

d. pier

5. When the depth of a girder is doubled how much is the safe load increased?

a. six times
b. five times
c. four times
d. three times

6. If the joists are to span the width of a 12′ x 24′ building and are to be spaced according to the accepted standard, how many will be required?

a. 20
b. 17
c. 15
d. 12

7. You are placing and anchoring joists. How much of the width of the joist should be supported at the sill and at the girder?

a. ¾ width
b. ½ width
c. ¼ width
d. full width

3-8



EDITION 0 (NRI 011)

8. You are installing trimmers and headers for a chimney. How far from each surface of the chimney in inches would you locate these to prevent the heat of the chimney from causing a fire?

a. 2 c. 5

b. 4 d. 6

9. Cross bridging distributes a concentrated load to several joists. What size material is used to make this bridging?

a. 1" x 4" c. 2" x 4"

b. 1" x 8" d. 2" x 8"

10. What structural members serve as anchors for the outside walls?

a. foundation walls

b. sills

c. wall frames

d. ~~wall studs~~

11. When constructing corner posts, you decide to use the built-up type rather than the solid. Why?

a. gives more nailing surface

b. allows more air circulation

c. eliminates bracing against horizontal forces

d. requires fewer nails

12. You have decided to use block bracing in the construction of a building. What advantage do you gain?

a. reduces nailing surface of the wall panels

b. allows use of 1 x 4 inch material

c. helps to keep the studs straight

d. permits vertical installation of 2 x 4's

13. If speed and ease of installation of service pipe and conduit are of first importance, what type of wall framing would you use?

a. braced

b. platform

c. balloon

d. theater of operations

14. All subflooring material should be fitted tightly. In using plywood sheets as a subfloor, how far apart in inches would you space the nails?

a. 2 c. 5

b. 3 d. 6

15. What is probably the most common type of door in use?

a. batten c. flush

b. solid d. panel

16. Vertical sliding doors are better known by what name?

a. overhead c. batten

b. sliding d. panel

17. The "rough" opening must be prepared for a window frame. The window sash is 36 inches wide. Pulley and weight balancing devices will be used. What is the least distance in inches that you will allow between trimmer studs?

a. 42 c. 34

b. 38 d. 30

18. Seventy-five window glasses measuring 24 x 24 inches must be replaced. If the sash is rabbetted ⅜ inch, how many gallons of putty will you need to bed and face glaze the glass?

a. 3 c. 6

b. 4 d. 7

19. What is the main supporting member in a frame roof?

a. ridge
b. rafter
c. plate
d. rise

20. What type of roof is often used to form other types of roof?

a. hip
b. gable
c. mansard
d. deck

21. What is the common spacing of rafters in inches?

a. 16 to 30
b. 16 to 28
c. 16 to 24
d. 12 to 20

22. You are installing rolled roofing. How many inches apart do you space the roofing nails?

a. 12
b. 10
c. 8
d. 6

23. You have decided to use asbestos shingles for the roof of a building that you are erecting. What must be the minimum rise (in inches) per foot run of the roof?

a. 4
b. 6
c. 8
d. 9

24. How many years can you expect a good quality slate roof to last?

a. 10
b. 25
c. 50
d. 100

25. How many inches apart do you space the studs of a non-weight-bearing partition wall?

a. 20
b. 22
c. 24
d. 28

26. Wood paneling may be constructed from various types of wood. What wood is most commonly used?

a. oak
b. birch
c. douglas fir
d. mahogany

27. You are installing an exterior door in a 6' 8" opening, using a threshold 1" thick. What length do you make the door?

a. 6' 6⅞"
b. 6' 8"
c. 6' 9"
d. 6' 7"

28. What is the least number of 9 x 9 inch tiles that you can use to cover floor that is 9 x 9 feet?

a. 164
b. 144
c. 140
d. 130

29. What is the preferred degree of slope from the horizontal for a stairway?

a. 30° to 35°
b. 30° to 40°
c. 25° to 42°
d. 20° to 45°

30. What would you use to attach non-slip nosings to stair treads?

a. pitch
b. cement
c. nails
d. screws